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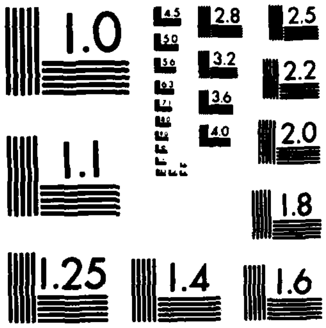
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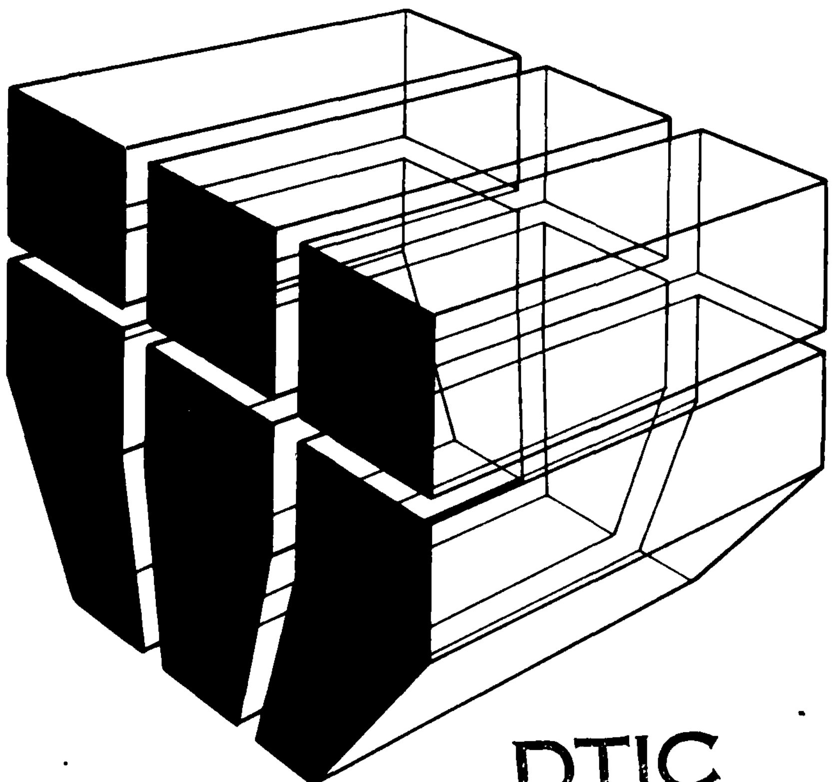
ENHANCEMENTS TO THE ECONOMIC IMPACT FORECAST SYSTEM (EIFS)

by
D. P. Robinson
R. D. Webster



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This report documents the methodologies of three systems selected for inclusion within the Economic Impact Forecast System (EIFS): the Bureau of Reclamation Economic Analysis Model (BREAM), the Regional Industrial Multiplier System (RIMS), and the Defense Logistics Agency Employment Impact System. These enhancements to EIFS will provide the user with more sophisticated economic modeling capabilities for evaluating the socioeconomic impacts of Department of Defense actions and programs. The enhancements will increase the overall utility of EIFS and will be available as an integrated system.

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FOREWORD

This project was performed for the Directorate of Engineering and Construction, Office of the Chief of Engineers (OCE), under Project 4A762720A896, "Environmental Quality for Construction and Operation of Military Facilities"; Task C, "Environmental Assessment"; Work Unit 004, "Development of Economic Impact Forecast System II (EIFS)." Mr. V. Gottschalk, DAEN-ECE, was the OCE Technical Monitor.

This research was made possible through the efforts of Department of Defense personnel, consultants from the University of Illinois, and scientists and engineers of the Environmental Division (EN), U.S. Army Construction Engineering Research Laboratory (CERL).

Administrative support and counsel were provided by Dr. R. K. Jain, Chief of CERL-EN. COL Paul J. Theuer is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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IMPACT FORECAST SYSTEM (EIFS)

1 INTRODUCTION

Background

Following the passage of the National Environmental Policy Act (NEPA)[1] in 1969, two executive orders[2] established that all Federal agencies must assess the environmental impacts of their major programs and actions, as well as provide leadership in environmental protection. Because of NEPA's requirement for assessing any impacts on the "quality of human environment," much discussion has surrounded the question of whether this mandate extends to the social and economic impacts of programs and actions. Many courts have decided that in preparing Environmental Impact Statements (EISs), adequate assessment of social and economic impacts is as important as assessment of biophysical impacts.

In the past, requirements such as the Case Study Justification Folder (CSJF) documentation for Department of the Army (DA) realignment actions provided for the identification of potential economic impacts and consideration of these impacts in the decision-making process. More recently, Department of Defense (DOD) guidelines have encouraged a uniform approach to socioeconomic impact assessment, so that all DOD agencies may benefit from a systematic approach and uniform documentation. The need for uniformity stems, in part, from the uniqueness and geographic distribution of DOD installations, their effects on local economies, and the complexity of problems associated with determining the social and economic implications of DOD realignment actions.

To address the need for a systematic approach to socioeconomic assessment, DA, with cooperation and support from the Department of the Air Force (USAF), has developed the Economic Impact Forecast System (EIFS),[3] which provides information useful for calculating social and economic changes caused by DOD actions. This computerized system is designed to be a user-oriented, inexpensive, and systematic approach to meeting NEPA requirements. Since its inception and implementation within the Environmental Technical Information

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[1] National Environmental Policy Act of 1970, 83 Stat 852, 42USCS4321, et seq. (January 1970).

[2] Protection and Enhancement of Environmental Quality, Exec. Order 11514, 35 F.R. (March 5, 1970); Prevention, Control and Abatement of Environmental Pollution at Federal Facilities, Exec. Order 11752, 38 F.R. 34793 (December 19, 1973).

[3] R. Webster, R. Mitchell, R. Welsh, E. Shannon, and M. Anderson, The Economic Impact Forecast System: Description and User Instructions, Technical Report N-2/ADA027139 (U.S. Army Construction Engineering Research Laboratory [CERL], 1976); R. Webster, et al., The Rational Threshold Value (RTV) Technique for the Evaluation of Regional Economic Impacts, Special Report N-49/ADA055561 (CERL, 1978).

System (ETIS),[4] DOD users have expressed a need for more sophisticated economic modeling capabilities within EIFS. Their needs include subcounty forecasting procedures, industry-specific regional multipliers, and economic modeling capabilities for areas with unique economic and demographic situations.

Objective

The objective of this report is to document the methodologies behind the development of three enhancements to EIFS (Version 3.0): the Bureau of Reclamation Economic Analysis Model (BREAM), the Regional Industrial Multiplier System (RIMS), and the Defense Logistics Agency (DLA) Employment Impact System. The addition of these concepts as part of EIFS will ensure that DOD planners have access to "state of the art" economic analysis procedures through ETIS.

Approach

The U.S. Army Construction Engineering Research Laboratory (CERL) reviewed several economic assessment methodologies and evaluated them relative to the needs and constraints of DOD planners. BREAM, RIMS, and the DLA Employment Impact System were selected for inclusion with EIFS and are explained and documented in this report.

Scope

This report is intended as a reference guide, addressing the technical documentation of the algorithms, economic methodologies, and databases for these three systems. It does not include principles of interactive computing, operation of computer terminals, or user instructions. The report is designed as a technical explanation of the theoretical issues and empirical procedures included within the new components of EIFS.

Because EIFS is an evolving system, new features and improvements are constantly being added. As they are added, announcements will be documented by system messages. When implemented, supplemental user guides and manuals will be written.

Mode of Technology Transfer

It is recommended that the information in this report be disseminated through the revision of Department of the Army Pamphlet 200-2, The Economic Impact Forecast System: Description and User Instructions. Concurrent with the revision, existing computer system documentation of the EIFS model will be altered to conform to Version 3.0.

[4] R. D. Webster, et al., Development of the Environmental Technical Information System, Interim Report E-52/ADA009668 (CERL, 1975).

2 BUREAU OF RECLAMATION ECONOMIC ASSESSMENT MODEL (BREAM)

Introduction

This section provides a technical description of the economic and demographic assessment model developed for the Bureau of Reclamation by Mountain West Research, Inc.[5] It is assumed the reader has some familiarity with the discussion of methodological issues and recommended procedures outlined in the Economic/Demographic Assessment Manual.[6] The discussion examines the logical underpinnings of BREAM so the structure of the model can be understood by people with some training in socioeconomic analysis techniques. A secondary purpose is to discuss the strengths and weaknesses of the model against competing methods, and to provide the user with the information needed to use the model effectively in various applications.

The overall objective of the modeling research performed for the Burea of Reclamation was to develop an operational tool that can be used to anal the interaction of economic and demographic activity, both with and withou various water resource development projects. Two important criteria for t development of the model were (1) that its structure be relatively simple understand, and (2) that it be able to serve as an overall framework to wh refinements could be added. Therefore, the model was constructed in a modular framework so existing elements can be modified and updated as advancements are made.

BREAM can best be categorized as an economic/demographic simulation model that analyzes the implications of different assumed inputs for a region's population, employment, and income. The root of this type of model can be traced to the Susquehanna River Basin Model developed by Battelle Memorial Institute.[7] The Susquehanna Model was the first to recognize both the interdependency and the need for consistency between the economic and demographic sectors. The concepts developed in this early model formed the basis for an economic/demographic model developed for San Diego, CA.[8] By the mid-1970s, this class of models was becoming better known and was being adopted by several states to produce county-level employment and population projections for general planning purposes. For example, UPED (Utah Process

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[5] This chapter is taken from the technical description of BREAM. J. A. Chalmers, et al., Bureau of Reclamation Economic Assessment Model (BREAM): Technical Description and User's Guide (U.S. Bureau of Reclamation, July 1981).

[6] J. A. Chalmers and E. J. Anderson, Economic/Demographic Assessment Manual (U.S. Bureau of Reclamation, November 1977).

[7] H. R. Hamilton, et al., Systems Simulation for Regional Analysis: An Application to River-Basin Planning, The MIT Press: Cambridge, MA (1969).

[8] Technical User's Manual for the Interactive Population/Employment Forecasting Model (San Diego Comprehensive Planning Organization, 1972).

Economic/Demographic Model) and EDPM (Arizona Economic/Demographic Projection Model) were developed at about the same time.[9]

Most economic/demographic simulation models have a similar structure built around three submodels. A demographic submodel accounts for population characteristics such as births, deaths, and the age/sex composition of the area. The supply of labor is determined from labor force participation rates and the "survived" population from the demographic submodel. An economic submodel determines labor demand derived from estimates of total employment. A labor market submodel then reconciles model/estimates of labor supply and labor demand. Labor market imbalances trigger either in- or out-migration from the area. Once labor market equilibrium is achieved, employment-migration is completed. The process results in projections of employment, income, and population in which the labor force associated with the population estimate is consistent with the employment estimate from the economic submodel.

Although BREAM has this same general structure, the three core submodels have been refined extensively. In addition, BREAM includes two other submodels. A construction worker submodel has been added to analyze the construction period impacts of large projects whose labor requirements exceed local supply. This submodel deals explicitly with assumptions concerning the mover/nonmover composition of the work force and the community allocation of the movers. A community allocation submodel has also been added to BREAM. This submodel takes county-level population estimates and allocates them to communities (or rural areas) within a county. Each of the five submodels of BREAM is summarized below and is depicted in Figure 1.

Demographic Submodel

The demographic submodel uses both vital rates and cohort-specific, base-year population to compute the effect of deaths and births on the existing county population. Further adjustments are made in the demographic submodel if there are subpopulations with distinct demographic characteristics, or if there is migration into or out of the area related to factors independent of local labor market conditions (e.g., retirement migration).

Construction Worker Submodel

The construction worker submodel may be used whenever a large construction project is being considered for which the demand for labor exceeds the labor supply available locally. Once the project's manpower requirements have been specified, the submodel analyzes user inputs to establish the residential location and demographic characteristics of the construction workers and their dependents.

[9] Report on the Development of the Utah Process (Utah State Planning Coordinator, 1972); Description and Technical Description of the Economic/Demographic Projection Model (Arizona Office of Economic Planning and Development, 1977).

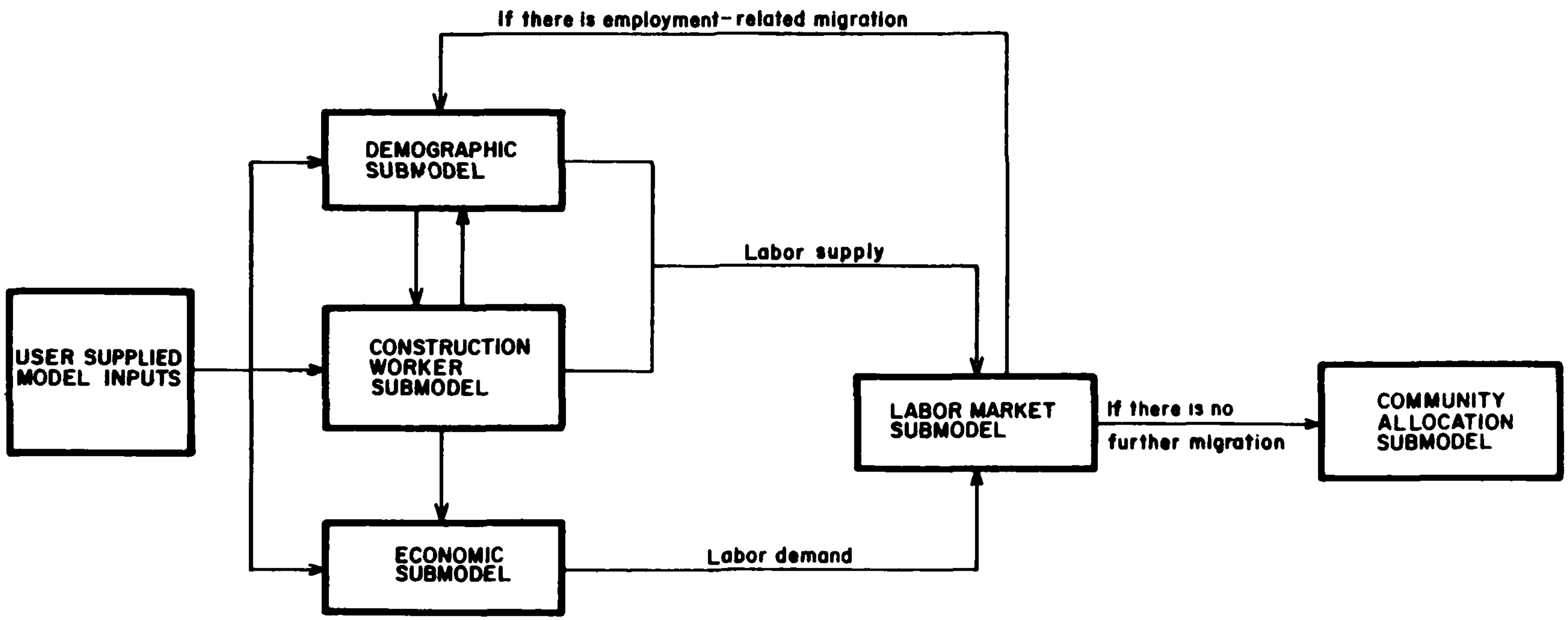

Figure 1. Structure of BREAM: Bureau of Reclamation economic assessment model.

Economic Submodel

The economic submodel is appropriately classified as an export base model that jointly determines the level of income and employment. Basic economic activity and externally determined income components are specified by the user. Total economic activity is then determined as a function of: (1) basic labor income derived from the projections of basic employment and average earnings, (2) nonbasic income determined by a set of industry- and area-specific equations that relate nonbasic employment to total personal income, and (3) nonlabor income. The simultaneous determination of income and employment depends primarily on the basic employment projections specified by the user.

An important innovation in the economic submodel of BREAM is that it explicitly accounts for intercounty trade relationships. For example, increased basic employment in a small county will stimulate employment and income in a larger county that serves as the regional trade and service center for the small county. Because BREAM deals with these relationships, it can be used for both single and multicounty problems.

Labor Market Submodel

The population calculated in the demographic submodel and the total employment estimate calculated in the economic submodel are evaluated for consistency in the labor market submodel. The locally available supply of labor is calculated by applying age- and sex-specific labor force participation rates to the resident population. Labor demand (number of persons, place of residence basis) is estimated by adjusting total employment (number of jobs, place of work basis) for multiple job holding and commuting. If the labor supply is in balance with the labor demand, no further adjustments are made to the population, employment, or income projections at the county level, and the model then progresses to the community allocation process. However, if there is an imbalance in the supply and demand for labor, in- or out-migration is assumed to occur until the imbalance is eliminated.

Community Allocation Submodel

Once equilibrium in the local labor market is established, county totals for population, employment, and income are fixed, and the population is allocated to communities within each county. School-age population for each community is also determined, and the implied number of households is estimated. The population is allocated by component of population change which allows differential allocation schemes for natural increase (births minus deaths), retirement migration, employment-related migration, and construction worker migration.

The remainder of this chapter examines each of the five submodels in detail. Particular attention is given to the overall logic and the empirical relationships used in each component. Following this discussion, a section on the strengths and weaknesses of BREAM is included to give the user a better understanding of the model.

Demographic Submodel

The demographic submodel serves as an accounting framework to keep track of an area's population characteristics. In particular, the demographic submodel records the components of the population change that occur from one year to another. The components of change include births, deaths, and migration.

Migration is usually the largest component of population change and therefore often determines whether a region's population is growing or declining. People typically migrate to or from an area to increase their well-being. Although the decision to migrate is complex, a number of factors influence it. For many regions, these decisions revolve strictly around economic issues. Lack of job opportunities or low wages in one area may stimulate a person to migrate to an area he/she perceives as having better job or wage opportunities. Although noneconomic factors such as climate, friends, relatives, or environmental amenities may influence the decision to migrate to an area, lack of adequate economic opportunities will prevent permanent relocation.

Another migration category is the type that is not motivated primarily by economic factors. A good example is people who are retired and are receiving income from various retirement programs, dividends, or personal savings. The movement of this type of person is determined by such noneconomic factors as climate and the location of friends and relatives. Another type of noneconomic migration includes movement for educational purposes or for military service.

The age and sex composition of an area's population is an important influence on some types of migration. In particular, an area that exhibits a young age distribution will typically have relatively high rates of in- and out-migration. The direction of the net flow of people will usually be determined by the nature of the economic (employment) opportunities occurring in the region relative to those occurring in the rest of the country.

The demographic submodel of BREAM uses a process known as "cohort-survival" developed in the 1920s by P. K. Welpton.[10] Cohort-survival models separately estimate births and deaths based on age- and sex-specific fertility and death rates, and on the population's age/sex structure. This allows the composition of the population to be taken into account in determining births and deaths. It also allows changes to be incorporated that account for the changing fertility and survival patterns of the population.

The following describes the details of the logic and assumptions of the demographic submodel. The text emphasizes the conceptual foundation of the model rather than its operational mechanics. Figure 2 summarizes the cohort-survival process used by BREAM.

Overview of the Cohort-Survival Process

The cohort-survival process is a relatively simple procedure. The primary input is the population of the area, disaggregated by age and sex.

[10] D. B. Pittenger, Projecting State and Local Populations (Ballard Publishing Company, 1976).

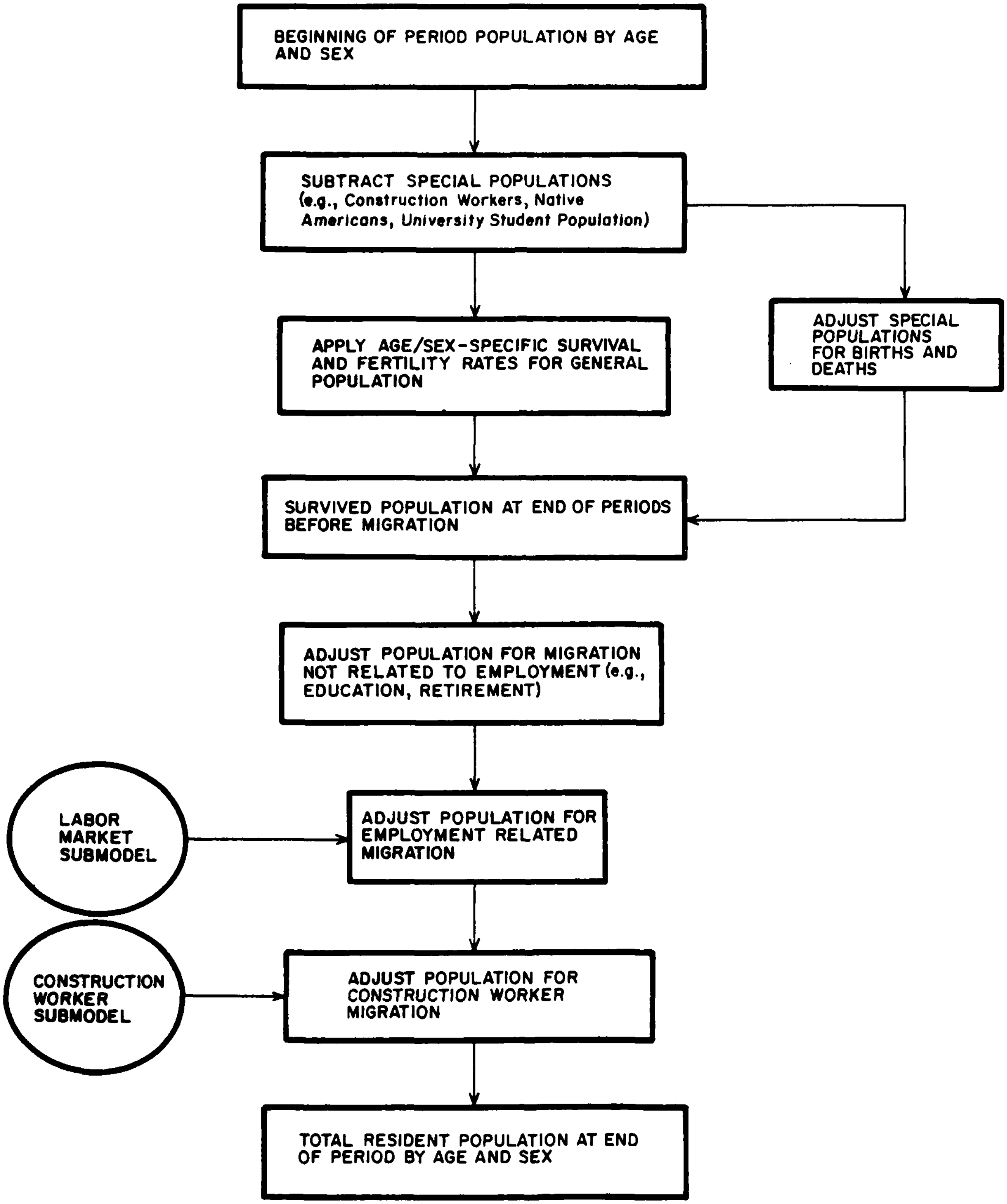

Figure 2. Demographic submodel of BREAM.

The first step in the process is to determine the number of deaths that will occur in each age group. This is done by multiplying the number of persons in each age and sex category by the corresponding death rate for that group. By subtracting the deaths from the population in each group, the number of people who will survive to the next age group is estimated. Thus, the number of 26-year-old males this year is equal to the number of 25-year-old males minus the number who are expected to die based on the death probabilities.

The next step in the cohort-survival process is to determine the number of live births expected to occur in the county over the year. Fertility rates, by age of mother, are multiplied by the number of females in each cohort, and then the total births are estimated by summing all the relevant female cohorts. Total births are then divided into males and females and included in the first cohorts of the survived population. If special subpopulations have been identified, deaths and births are calculated in the same manner as for the general population, except that vital rates relevant to the subpopulation are used. These calculations yield an estimate of the survived population at the end of the period prior to consideration of migration.

Migration in BREAM is one of the three general types identified above. There is migration not related to employment (e.g., retirement migration), there is employment-induced migration (as determined by a comparison of the supply of and demand for labor in the labor market submodel), and there may be the migration of construction workers and their dependents as determined in the construction worker submodel. Addition of the net migration flows to the survived population yields an estimate of the total resident population of an area at the end of the period by age and sex.

Benchmarking the Population

The age and sex information required for the population data causes a consistency problem between the demographic and economic submodels. The inconsistency occurs because the detailed population data are usually available only from the latest census of the population. However, the economic data are typically more current. Thus, the latest detailed population data available may be for 1970, while the economic data are for a later year. It is important that both data sets are for the same year when BREAM begins to forecast economic and demographic activity. A benchmarking procedure is used to move the population data from the census year to the last data year specified by the user. The last data year is defined as the year prior to the first forecast year.

For each year that the demographic data must be moved forward, a cohort-survival process is used to estimate the survived population. If the number of actual births is known, that figure is entered for the first cohort rather than using the estimate based on the fertility rates. The final step is to adjust the survived population to the population estimate that is supplied by the user. The ratio of the population estimate to the total survived population is used to adjust the individual age and sex cohorts proportionally.

Special Populations

A major modification to the traditional cohort-survival process that has been incorporated into the BREAM demographic submodel is an accounting for

certain special populations that may be in the area. The most significant use of this feature is for areas in which there are a relatively large number of native Americans in the population. Since this group often has a different age/sex structure and different vital rates than the rest of the population, it is desirable to analyze them separately. However, it should be noted that special populations would ordinarily be introduced only if three criteria are met: (1) the special population is a significant proportion of the general population (10 percent may be a reasonable rule of thumb), (2) vital rates and the age/sex structure of the special population are significantly different from the general population, and (3) migration is not an important source of change in the size of the special population. The last criterion is necessary because BREAM cannot presently estimate employment-induced migration for special populations, nor is it possible for the user to specify construction worker migration or migration not related to employment for special populations. Thus, the principal application of this option is to situations in which a special population has distinct demographic characteristics and is relatively immobile.

BREAM accounts for two other kinds of special populations: university students and construction workers. In both of these cases, the age/sex structure of the group remains relatively constant because of turnover in the group. For example, areas with a large university have a relatively large proportion of their population in the 18- to 22-year-old age group.

If this group is not accounted for as a special population, the bulge in the resident population will age and slowly move through the age groups. To prevent this from happening, the college-related population is removed from the resident population before the cohort-survival process is begun. Once births and deaths are calculated, the special population is added back. In effect, this keeps the age/sex distribution of the college population constant.

Construction workers who are temporarily located in an area to work on a large project are also incorporated in BREAM as a special population. Since the demographic characteristics of this group differ significantly from those of the general population and the age distribution of this group does not change, they are treated separately from the resident populations and are not included in the cohort-survival process. Therefore, the demographic structure of the construction worker population remains constant.

Vital Rate Adjustment

An important consideration in the projection of demographic characteristics is future changes in vital rates (fertility and death rates). The two basic questions are: (1) how will fertility and mortality characteristics change nationally as values and attitudes change and as medical technology improves?, and (2) how will regional vital rates change relative to the national trends?

There are usually differences between local (either county or State) and national vital rates. Education, access to medical care, religious beliefs, and various environmental issues are all possible explanations for the differences. Therefore, once national rates have been projected, the question becomes whether these differences will diminish, remain the same, or increase

over time. To account for these possibilities, BREAM incorporates various options that the user can select to determine the area-specific vital rates during the projection period. The first option is to keep the rates constant at the values entered for the base year. Since national fertility and death rates are projected to decline, this option will result in an increasing gap if the area rates are above the national rates, or in a diminishing gap if the rates are below the national rates. The second option is to allow the area-specific rates to change at the same rate as the national rates which, in effect, preserves the gap between the two n relative terms. The third option is to allow the area-specific rates to converge to the projected national rates by the year 2000. If either the second or third option is chosen for fertility rates, the user must also specify which of three national fertility rate projections will be used to adjust the area rates. The three projection series represent total births per female of 2.6, 2.0, and 1.6, respectively.

Migration

Employment-induced migration is determined in the labor market submodel, and construction worker migration is determined in the construction worker submodel. Each is discussed in more detail below in the context of the submodel in which they are determined. Migration unrelated to employment is the third type of migration accounted for by BREAM.

The primary type of nonemployment-related migration that has been incorporated in BREAM is retirement migration. The user must specify the level of retirement-related migration expected to occur in the area. This group includes persons 60 years of age and older. The user must also specify how the retirement migration is to be allocated among the relevant age groups.

Another type of nonemployment-related migration included in the model is the out-migration of persons aged 17 and 18 years old from the area in response to the educational or military opportunities that follow graduation from high school. These are entered as the proportion of each age/sex group that is expected to leave the area each year. Generally, this adjustment is only warranted in areas that have no institution of higher education.

Construction Worker Submodel

An important use of BREAM is to analyze the economic and demographic implications of major construction projects. Critical to this analysis is the determination of the likely source of the construction work force, the residential locations chosen by the workers who move in order to work on the project, and the number of dependents who accompany the movers.* Given this information, the construction worker submodel is able to provide necessary data on the size of the increase in basic income to the economic submodel. The overall structure of the submodel is shown in Figure 3.

*Movers (also referred to as nonlocals) are those workers who have changed their place of residence (during the work week) in order to work on a project.

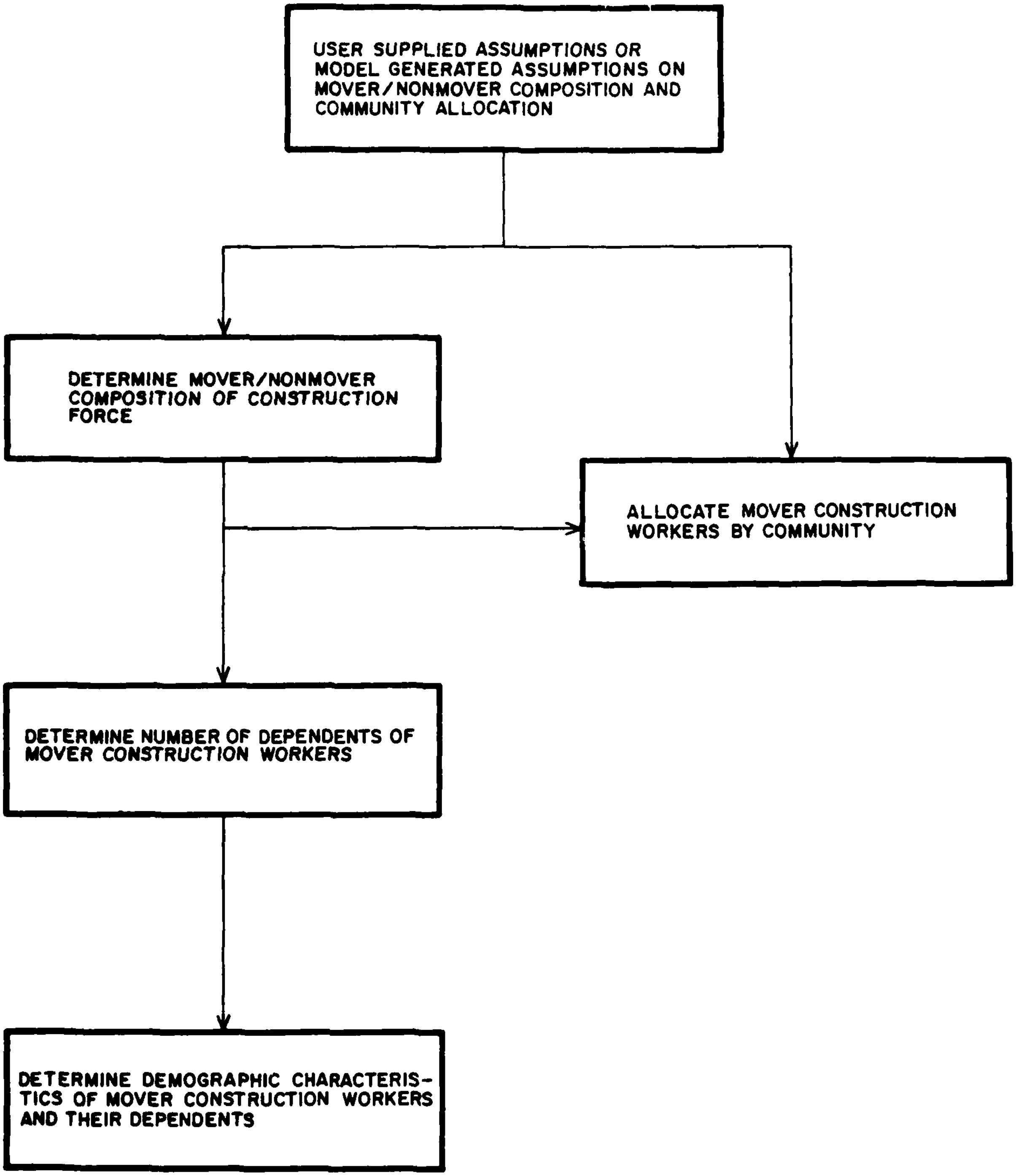

Figure 3. Construction worker submodel of BREAM.

The mover/nonmover composition of both the construction work force and the distribution of the workers by community can be estimated by the user and provided as input to the model, or it can be estimated internally within the model. Whichever option is chosen, the construction worker submodel generates internal estimates of the number and of the age/sex composition of the persons accompanying the construction workers.

User-Supplied Inputs

The user-supplied input needed to run the construction worker submodel consists of a set of proportions that sum to one. Table 1 illustrates the necessary information. All "communities" need to be identified that are the potential source of nonmover workers (locals) or which could potentially serve as a place of residence for movers (nonlocals). These communities can be defined to include any area convenient for the analysis. For example, in addition to well-defined communities in the area, the remaining rural area of a county could be defined as a community, or several smaller communities could be lumped into a single unit.

The next step in the process is to determine the proportion of the construction work force available locally. Table 1 indicates that 70 percent of the construction work force is nonmovers, i.e., available local workers. Appropriate estimates for these proportions can usually be considered best in terms of absolute numbers of workers. Therefore, it is useful to think in terms of the total number of workers required at the peak of construction. Suppose 500 workers were required at the peak. Table 1 suggests that 350 of them could be supplied locally: 125 from Community A, 125 from Community B, and 100 from Community C. If only 70 percent of the construction labor requirements can be met by nonmovers, then clearly 30 percent, or 150 workers, must be met by movers. The final task to complete Table 1 is to assign the movers to communities. The assumption in Table 1 is that 50 of the movers will relocate to Community A, 25 to Community B, and 75 to Community C.

Fortunately, there is an increasingly large body of primary data that can be used to develop the necessary estimates. Table 2 summarizes six of the most important recent studies of construction worker data. Together, these studies represent information on nearly 100 projects scattered throughout the United States. Particularly relevant for water resource planners are the studies of 12 water projects by the Bureau of Reclamation[11] and the more recent study by the Institute for Water Resources of 55 water projects.[12] The work by Dunning is particularly useful because of the large number of water projects studied and because he presents several tables that compare the results of his work with those of previous studies.

Generally, the conclusion emerges from previous research that on the average, many of the important relationships appear to be remarkably similar for different types of projects and for different parts of the country. However, it is also true that there is still much variation among projects.

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[11] J. A. Chalmers, Bureau of Reclamation Construction Worker Survey (Bureau of Reclamation, Engineering and Research Center, 1977).

[12] C. Mark Dunning, Report of Construction Worker Survey (Institute for Water Resources, U.S. Army Corps of Engineers, 1981).

Table 1

Hypothetical Mover/Nonmover and Community Allocation Factors for Construction Worker Submodel

	Nonmovers	Movers
Community A	0.25	0.10
Community B	0.25	0.05
Community C 1/	0.20	0.15
	0.70	0.30

1/ One of these "communities" can, in fact, represent a rural area or a group of communities or any area convenient for the analysis.
Source: Mountain West Research, Inc., 1981.

Table 2

Recent Construction Worker Surveys

	Date of survey	No. of projects	No. of responses	Response rate	Location of projects	Type of projects
Institute for Water Resources (Dunning, 1980)	1979	55	4,989	0.65	U.S.	Water
Bureau of Reclamation (Chalmers, 1977A)	1977	12	692	0.52	West	Water
North Dakota State University (Leholm, et al., 1976)	1975	2	254	0.24	North Dakota	Electric Generating (Coal)
Nuclear Regulatory Commission (Malhotra, S. and D. Manninen, 1979)	Various	13	1/	NA	U.S.	Electric Generating (Nuclear)
Tennessee Valley Authority (DeVeny, 1977)	1968-1975	6	1/	NA	Southeast	Electric Generating
Old West Regional Comisission (Mountain West Research Inc., 1975)	1975	14	3,168	0.50	West	Mining and Electric Generating (Coal)

1/ Number of responses is very large because response rates are high and because individual projects were often surveyed several times.
Source: Mountain West Research, Inc., 1981.

Thus, although average relationships from the work by Dunning or Chalmers would be a reasonable starting point for the distribution of the workforce between movers and nonmovers, discussions with knowledgeable local contractors, union business managers, and planners should be heavily weighted in making final assumptions about the ability of the local area to supply workers.

Assumptions with respect to the community distribution of movers need to reflect local input even more heavily. It is well documented that the community distribution of mover construction workers will be closer to the project site than for nonmovers, and that distance from the site is the principal decision variable.[13] Nevertheless, the nature of the local transportation system and the availability of accommodations will be important determinants of settlement patterns that require local input.

The mover/nonmover composition of the construction work force and the community allocation of the movers are major determinants of both the magnitude and the spatial distribution of the socioeconomic impacts of a construction worker submodel, so the data in Table 1 are necessarily somewhat arbitrary; therefore, it will often be important to solicit public involvement in making these assumptions and in evaluating the implications of different assumptions.

Model-Generated Inputs

In using the construction worker submodel, primary reliance should always be placed on assumptions, with respect to mover/nonmover composition and community allocations that are generated and carefully evaluated by the user. The construction worker submodel provides internally generated estimates of these key parameters based on average relationships derived from data collected at 12 water-related construction projects in the West. The database and the empirical procedures used to derive the equations used in the construction worker submodel are reported by Chalmers.[14] It may be possible to update these relationships based on the more recent work by Dunning,[15] however, at present, the average relationships from the energy projects are the only usable set of results. The principal use of this option should be to provide a starting point for the user in developing site-specific estimates of the work force composition and allocation assumptions. The main reason for this is that all the construction worker studies have shown that there is large variation among projects. For example, among the energy projects studied by Chalmers, the nonmovers ranged from 3.3 to 78.6 percent of the workforce.[16] Therefore, it is clearly necessary that conditions particular to each project be scrutinized to prevent serious prediction errors.

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[13] S. Malhotra and D. Manniven, Socioeconomic Impact Assessment: Profile Analysis of Worker Surveys Conducted at Nuclear Power Plant Construction Sites (Battelle Memorial Institute, 1979).

[14] J. A. Chalmers, "The Role of Spatial Relationships in Assessing the Social and Economic Impacts of Large-Scale Construction Projects," Natural Resources Journal, 17 (1977), pp 209-222.

[15] Report of Construction Worker Survey.

[16] Bureau of Reclamation Construction Worker Survey.

If the user chooses the option of having the model generate assumptions, the first step is to determine the mover/nonmover composition of the construction employment associated with a project. This division is calculated for the peak year of activity and is then used for the other years during which there are construction workers on the project. The number of nonmover workers that may be supplied by the local labor market is estimated by relating the size of each community and its distance from the project to the size of the project in terms of peak-year employment. The total number of nonmover construction workers for the project is found by summing across the communities. The mover workforce is the difference between the total project construction workforce and the number of workers supplied by the local area. Specifically, it is assumed that the number of nonmover workers supplied by a particular community to a given project is:

1. Positively related to the size of the community

2. Positively related to the size of the project

3. Inversely related to the distance from the project to the community

4. Inversely related to the presence of other communities within commuting distance of the project.

The equation, as derived by Chalmers,[17] which is used to calculate the number of nonmover construction workers that could be expected to be supplied by a particular community is:

$$NMCW_{ij} = 0.018 POP_i^{.445} E_j^{*.981} D_{ij}^{-.512} \sum_i POP^{-.119} \qquad \text{[Eq 1]}$$

where the variables are defined as:

$NMCW_{ij}$ = nonmover construction workers supplied by community i to project j

POP_i = population of community i

E_j^* = peak employment on project j

D_{ij} = distance from community i to project j

$\sum_i POP$ = total population of communities supplying local workers.

Summing $NMCW_{ij}$ over all communities and dividing by the project construction employment in the peak year yields the proportion of construction workers calculated to come from the local area.

[17] "The Role of Spatial Relationships in Assessing the Social and Economic Impacts of Large-Scale Construction Projects."

For project j, the proportion of local workers would be:

$$PNMCW_j = \sum_i NMCW_{ij} / E_j^*$$ [Eq 2]

where:

$PNMCW_j$ = proportion of construction employment on project j who are nonmovers

This proportion, applied to the project construction employment (E) for each year, gives the number of nonmover workers for the other years of project construction. The difference between the total number of workers and the number of nonmover workers is the estimate of the number of mover workers.

Thus, for project j, the number of mover workers (M_j) for a given year would be:

$$M_j = E_j - (E_j \times PNMCW_j)$$ [Eq 3]

The next step is to allocate the mover workers to communities in the local impact area. This allocation is based on the following method. Community attractiveness is assumed to be a positive function of community size and an inverse function of distance between the community and the project. Where MA_{ij} is the number of mover workers locating in community i from project j, it is assumed, based on the results of Chalmers[18] that:

$$MA_{ij} = POP_i^{.385} D_{ij}^{-.639}$$ [Eq 4]

The proportion of mover workers allocated to a particular community is calculated as MA_{ij} by the MA_{ij}'s summed over all the communities in the local impact area. This will be used in the community allocation procedure described later and is of the form:

$$MAC_{ij} = MA_{ij} / \sum_{i=1}^{n} MA_{ij}$$ [Eq 5]

where:

MAC_{ij} = Proportion of mover construction workers on project j who will choose to live in community i

n = number of communities in the local impact area

[18]"The Role of Spatial Relationships in Assessing the Social and Economic Impacts of Large-Scale Construction Projects."

[illegible]

The next step in the construction worker analysis is to determine the age structure and family composition of the mover construction workers. Age distribution factors derived from the <u>Construction Worker Profile</u>[19] are shown in Table 3 and are used to allocate the total number of mover construction workers to specific age groups. To determine the family composition of the mover workers, an average married-with-family-present rate is used. The rate of 47.5 percent from the <u>Construction Worker Profile</u> implies that there will be almost 48 spouses, or families, for every 100 mover construction workers for the project. The spouses are assumed to have the same age distribution as the workers. It is also determined in the <u>Construction Worker Profile</u> that, on the average, there will be 1.61 children per family with the age distribution that is given in Table 4. This means that for every 100 mover construction workers, there will be an average 52.5 workers who are single or married but without their families, and 47.5 workers who are married with their families present (47.5 spouses and 78.9 children), for a total of 226 persons per 100 mover workers. Dunning's more recent work indicated an average influx of 224 persons per 100 movers.[20] However, it is important not to misinterpret the fact that there is substantial agreement in the averages in these different studies, since there continues to be substantial variation among individual projects.

Coincident Projects

For areas in which the construction of more than one project is expected during the projection period, two options can be followed. The first option should be used when the peak employment for two or more projects in the area is expected to occur at about the same time. This case will be referred to as that in which two or more of the projects are coincident. The second option should be used when the projects are discrete; that is, they do not overlap significantly.

If the projects are discrete, there is no change in the processes described above, except that the construction worker submodel is accessed as many times as there are projects, and each project is analyzed independently. However, if two or more projects are coincident, the process of determining the mover/nonmover division is as follows. The peak year becomes the year for which the combined employment for the projects is greatest. The number of nonmover workers for the project beginning earlier is determined first, using the equation previously presented. The next step is to add the employment in the same year for the second project to the employment associated with the first project:

$$E^* = E_1^* + E_2^* \qquad \text{[Eq 6]}$$

[19] Mountain West Research, Inc., <u>Construction Worker Profile: Final Report</u> (Old West Regional Commission, 1975).

[20] <u>Report of Construction Worker Survey</u>.

Table 3

Allocation Factors for Age Distribution of Mover Construction Workers

Age	Factor 1/
15-17	--
18-19	0.03400
20-24	0.03400
25-29	0.04060
30-34	0.04060
35-39	0.01590
40-44	0.01590
45-64	0.00985

1/ The factor is used for each single year of age within the corresponding age category.
Source: Mountain West Research, Inc., 1975, Construction Worker Profile: Final Report, a study for the Old West Regional Commission, Washington, D.C., p 38.

Table 4

Allocation Factors for Age Distribution of Children Accompanying Mover Construction Workers

Age	Factor
0	0.1184
1	0.1184
2	0.1184
3	0.1184
4	0.1184
5	0.0845
6	0.0845
7	0.0845
8	0.0845
9	0.0845
10	0.0845
11	0.0845
12	0.0629
13	0.0629
14	0.0629
15	0.0629
16	0.0629
17	0.0629
18	0.0613

Source: Mountain West Research, Inc., 1975, Construction Worker Profile: Final Report, a study for the Old West Regional Commission, Washington, D.C., p. 33.

A combined distance factor is then calculated for each community in the study area. This takes the form:

$$D^* = (E_1^*/E^*)\ D_{i1} + (E_2^*/E^*)\ D_{i2} \qquad \text{[Eq 7]}$$

Both E* and D* are used in the nonmover worker equation and the result is interpreted as the number of nonmover workers from each community for both projects 1 and 2. Since the number associated with the first project has already been calculated, this is subtracted from the combined total, which gives the number of nonmover workers associated with the second project. If there are three proposed projects that coincide, the procedure is to calculate the combined project employment for the peak year and the weighted distance factor and then compute the total nonmover workers for the combined projects. The number of nonmover workers calculated for the two combined projects is subtracted from the number for the three combined projects, and the result is the number of nonmover workers associated with the third project. Once the number of nonmover workers for each project has been calculated, the number of mover workers and the community allocation of these workers are calculated as before.

After the analysis has been completed for all the projects under consideration, the total number of mover construction workers in each county is calculated by summing over all the projects. The number of nonmover construction workers in each county who work on the projects is added to the total mover construction work force. The total number of construction workers in each county is added to the baseline levels of basic construction employment for each county for use in the model's economic component.

Economic Submodel

Current research in regional economic modeling, particularly that related to impact assessment, has revealed that there are strong similarities among input/output, export base, and econometric models.[21] The multipliers (a measure of the increase in total economic activity in response to an increase in basic activity) derived from the three approaches have been demonstrated to be consistent, both theoretically and empirically. Therefore, economic modeling had become increasingly eclectic, often using aspects of all three techniques. The pragmatic differences among the methods lie in four areas:

1. The extent of the sectoral disaggregation
2. The database from which they are estimated
3. The questions that they are best suited to answer
4. The extent to which they can incorporate alternative assumptions and data parameters.

[21] A more detailed description of the different modeling alternatives can be found in J. A. Chalmers and E. J. Anderson, Economic/Demographic Assessment Manual (U.S. Bureau of Reclamation, 1977).

Input/output models are usually characterized by a high level of industrial disaggregation since they are estimated from relatively detailed interindustry transactions data. Their principal concern is incremental analysis based on given changes in final demand rather than the determination of the levels of final demand. Econometric models have little, if any, industrial disaggregation, and are usually estimated based on a large number of time-series observations. This type of model is most frequently used to forecast baseline levels of economic activity based on historical trends, and is particularly relevant to projecting activity for large and relatively complex urban areas.

Export base models are less easy to characterize because of the variety of ways in which they can be constructed. The essential difference among export base models is the level of disaggregation of the economic sector. The export base model may range from a single ratio or multiplier, which relates a change in basic activity to the total change in economic activity, to a matrix of multipliers, which indicates each economic sector's response to a given change in basic activity. Most techniques used to quantify the multipliers are based on data for a given point in time, although some use time-series data. The export base approach is amenable to projecting levels of activity or to estimating incremental changes in economic activity. It is commonly used for both purposes.

At the level of analysis required for impact assessment, an input/output model based on primary data is not likely to be a reasonable alternative. Its development is expensive, and the technique suffers from the limitation of only representing the structure of the economy at the time that the primary data survey is taken. This is potentially a serious problem, since a major consequence of a proposed action may be to change the structure of the local economy and render the interindustry transactions data obsolete, especially in the case of relatively large activities in sparsely populated areas. The second issue is that input/output techniques are less appropriate if the level of industrial interaction in a region is low. In many areas, there may be no, or very few, local purchases of intermediate goods, which limits the relevance of the input/output model.

For a larger region, the shortcomings of input/output are much less serious since the proposed action is rarely so large that significant structural change would be expected to occur in the economy. In addition, since there are usually significant levels of interindustry transactions in large areas, input/output analyses yield important information. However, for purposes of economic modeling for small rural areas, these factors are not as important.

The arguments made above are not intended to imply that existing data on interindustry transactions can be ignored in small counties. On the contrary, existing data have to be carefully reviewed, and whatever modeling technique is adopted, the researcher must be convinced that important backward or forward linkages have been incorporated adequately. However, the fact remains that although existing input/output models will continue to be used for small area impact analysis in the few cases where up-to-date data exist, it would be

unusual to conduct primary data surveys in order to construct an input/output model for this purpose.

Much more common, and at the other end of the continuum from input/output in terms of complexity, is the simple export base model. In the extreme case (not uncommon in the assessment literature), employment by a one-digit industrial sector is categorized as basic or nonbasic on a priori grounds (e.g., manufacturing is basic, transportation is nonbasic). The ratio of total employment to basic employment for a particular year is then used to project the change in economic activity, given a change in basic activity. The more important issues ignored by this approach include the following:

1. Basic employment has to be weighted to reflect earning differentials. It makes little sense to suggest that a change in tourist-service trade employment will have the same effect on the economy as a change in the heavy construction industry.

2. Explicit account must be taken of linked or indirect basic activity.

3. Even a modest goal like achieving "ballpark accuracy" for the multiplier demands rigorous attention to the split between basic and nonbasic. For example, much of the manufacturing in the West is nonbasic, while much of transportation is direct or indirect basic. Both examples are contrary to traditional a priori categorization.

4. If significant growth is anticipated in the economy of the local impact area, account must be taken of the fact that more locally produced goods and services will become available (import substitution). The result is that the effective multiplier will increase.

5. Finally, trading relationships within the local impact area have to be examined because activity in one area may depend on activity levels in surrounding areas. These interarea trading relationships may be critical to understanding the spatial distribution of economic impacts.

General Model Framework

The economic submodel of BREAM is appropriately classified as an export base model that produces consistent forecasts of employment and income. It postulates that total economic activity is determined by basic labor income, nonbasic labor income, and nonlabor components of personal income. The model has evolved from practical experience in carrying out impact assessment and forecasting projects in the Western United States and incorporates procedures that overcome many of the shortcomings of simple export base models.

Figure 4 shows the general framework of the economic submodel of BREAM. Beginning with basic employment projections supplied by the user, basic income is calculated by multiplying basic employment by sector-specific annual wage rates. The initial basic income estimate, together with an initial estimate

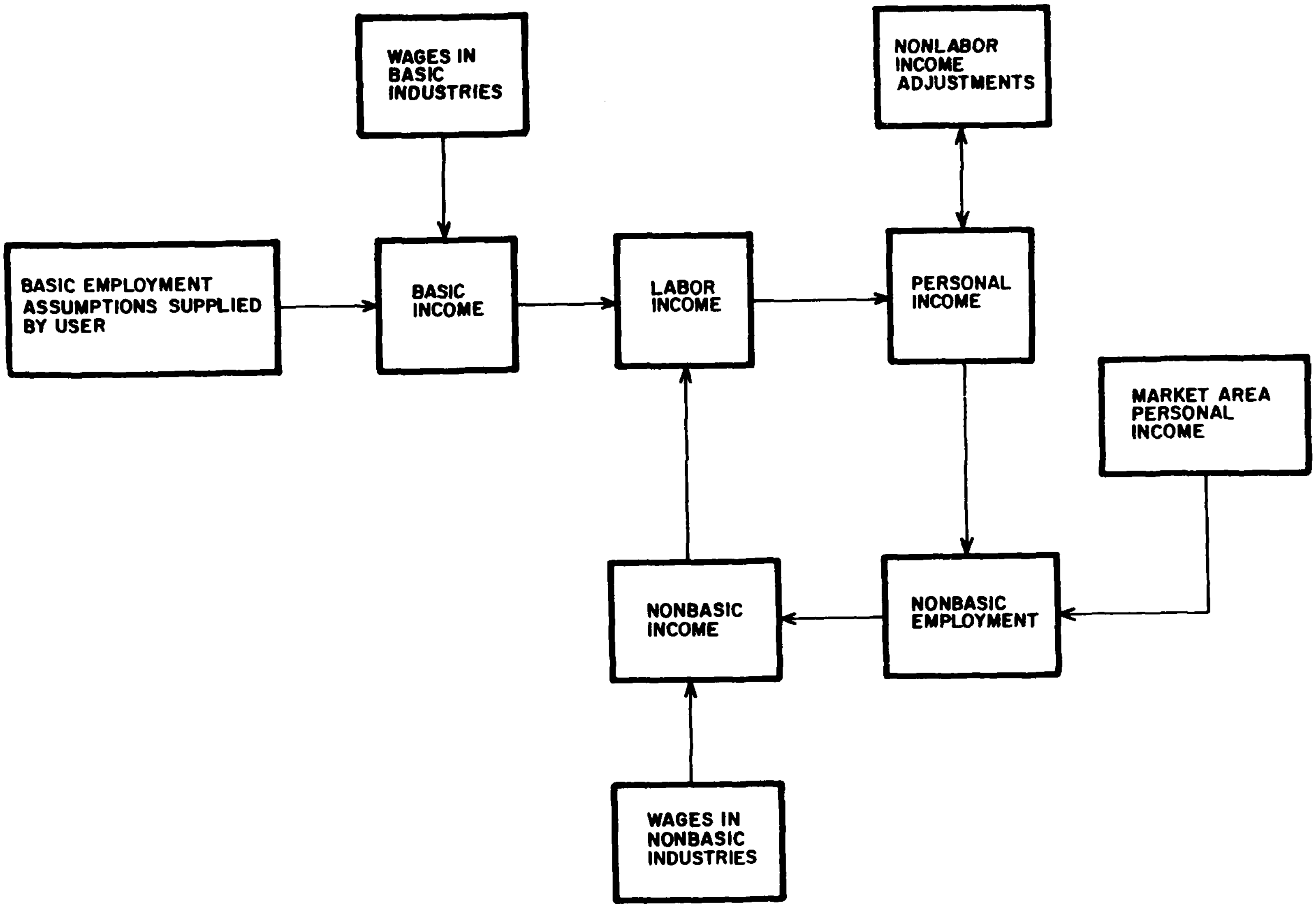

Figure 4. Economic submodel of BREAM.

of nonlabor income adjustment,* result in an initial estimate of personal income. Nonbasic employment is then estimated based on personal income; if the area is a trade and service center for other areas, it is based on the personal income in its market area. Nonbasic income can then be estimated based on the employment estimate and the wage data, and is added to labor income. This results in a new estimate of personal income. The calculations of nonbasic employment and income and of nonlabor income are then repeated using this new level of personal income. Since any change in personal income is assumed to affect nonbasic employment and a change in nonbasic employment affects income, the iterative process must be continued until a consistent level of personal income and nonbasic employment is established. Since basic income is determined through the basic employment projections supplied by the user, it is not affected by these iterative changes in the level of personal income and nonbasic employment. The interrelationships among the components of the economic submodel are discussed in detail below. Particular emphasis is placed on determining nonbasic employment and personal income.

Basic Labor Income

Basic Employment Assumptions. The primary input to the economic submodel is the basic employment assumptions supplied by the user. Within the structure of BREAM, basic economic activity is defined as that economic activity within the study area wholly determined by forces originating from outside the study area. This commonly includes activity associated with exported goods and services, but may also include tourist-related business and some Government activity. Nonbasic (induced) activity is that economic activity determined by the level of economic activity within the general study area. In addition, when a county serves as a regional trade and service center, nonbasic employment in BREAM includes that employment which results from personal income in the counties in the center's market area.

While the conceptual distinction between basic and nonbasic employment can be established, there are many practical problems associated with delineating actual employment according to its basic/nonbasic composition. There is substantial literature in regional economics and economic geography that deals with the diverse methodologies that can be used. A detailed summary of these techniques is available in the Economic/Demographic Assessment Manual.[22] After having identified the present levels of basic employment in the local economy, the next step is to project basic employment for each of the model's economic sectors for the course of the projection period. The length of the projection period is often determined by the planning or assessment guidelines under which the study is being directed. However, it should be noted that there can be large variations in the level of effort appropriate to construction of the basic employment forecasts. The complexity of the economy and existing research and data pertaining to the

*Nonlabor income includes all forms of personal income that are not received in the form of wages, salaries, and proprietor's income. Nonlabor income includes transfer payments and dividends, interest, and rent. In addition, two other adjustments are made to derive total personal income. Personal contributions for social insurance are subtracted, and a residency adjustment is made to account for intercounty commutations.

[22] Economic/Demographic Assessment Manual.

study area will generally dictate the magnitude of the effort. Again, the user is referred to the Economic/Demographic Assessment Manual for specific details of the basic employment projection process.

Real Wages. Although basic employment projections are the primary input, the model uses personal income in its calculations. Consequently, basic labor income must be calculated as the first step of the process. The user supplies average earnings by industrial sector, which is then used to compute the basic labor income. The average earnings are calculated for the base year from the most recent BEA personal income and employment data. Methodological problems may complicate the calculation. First, nonagricultural proprieter's income is allocated across the economic sectors by the BEA, while the number of proprietors is not. Therefore, the average earnings figure associated with each wage and salaried employee is composed of a wage and salary earnings component and a proprietor's income component. Total income in each sector is computed as the product of the combined earnings per employee factor and wage and salary employment.

The second complexity involves the fact that the economic submodel's calculations are in terms of real income. Consequently, an adjustment is made to account for expected annual changes in productivity and the related changes in real average earnings.

Determining Nonbasic Employment

The Relationship of Nonbasic Employment to Income. Nonbasic employment is defined as activity that originates as a response to forces within the local area or within the market area. The determination of nonbasic employment (that is, the exact nature of the response to income) has been the subject of much research in regional economics. The central problem is that most industrial sectors have components of both basic and nonbasic activity. These components must be clearly identified and separated to produce reasonable estimates of the responsiveness of nonbasic employment to changes in the causal variables.

The procedure used to estimate the economic submodel disaggregates employment data in each one-digit industrial sector into the basic and nonbasic components. Once nonbasic employment is estimated, each sector's response to local income (a coefficient referred to as a "gamma") is calculated as the ratio of nonbasic employment to personal income. These sectoral gammas then become the means to forecast the nonbasic employment resulting from the projected levels of personal income.

Trading Relationship. A major issue in economic impact analysis is that the consequences of an action will not be confined to a single area, but will permeate a region according to the economic trading relationships that join them. The response of the economy to a change in economic activity would be expected to be the same for all regions if consumption patterns of consumers were the same and if nonbasic activity was dispersed in proportion to income distribution. Although there undoubtedly are differences in consumption patterns in given income levels, it probably can be assumed that, within a given region, these differences are not significant at the one-digit SIC (Standard Industrial Classification) level of analysis. More important is the existence

of an economic hierarchy among areas in which more sophisticated and specialized goods and services are available only in larger places. This has the obvious consequence that the nonbasic employment response to a given change in personal income will be greater in larger areas; i.e., the gammas will be larger.

The development of the trading relationship concept can best be described through an example. Given a region composed of two areas (A and B), assume that A is much larger than B, and that A serves as a trade center for the region. Households and businesses in A can purchase a broader range of goods and services locally than can the consumers residing in B. Consequently, the economy of A can support relatively more nonbasic economic activity (retail trade for instance), given a level of basic activity. In addition, residents of area B purchase certain goods and services in area A.

Algebraically, the relationship between NBE (nonbasic employment) and PI (personal income) can be represented as:

$$NBE_{j,B} = f\ (PI_B)$$

$$NBE_{j,A} = f\ (PI_A,\ PI_B)$$

That is, nonbasic employment in sector j (e.g., trade) in area B depends only on the level of income in B, but nonbasic employment in sector j in area A responds to income in both areas. The point is that there are some specialized goods and services that are not readily available in area B for which residents of B must travel to area A.

It is useful to refer to the goods and services available in area B as first-order goods. These represent those items or services that are commonly available even in very sparsely populated areas. The goods and services that can be obtained only in area A are defined as second-order (e.g., goods and services of a higher-order specialization). Residents of the less populated area B satisfy their first-order demands in area B (by definition) and their second, and possibly higher-order demands in area A; however, residents of area A get both their first- and second-order goods and services locally. This leads to the following:

Define:

γ_j^1 = first-order demand for activities in sector j

γ_j^2 = second-order demand for activities in sector j

Accordingly, the relationship between nonbasic employment and personal income mentioned above can be more precisely represented as:

$$NBE_{j,B} = \gamma_j^1\ PI_B \text{ and}$$

$$NBE_{j,A} = \gamma_j^1\ PI_A + \gamma_j^2\ (PI_A + PI_B)$$

The importance of the spatial interaction between the two economies must be emphasized. If the effects of a proposed project in county B are analyzed without taking into account the trading relationships, the aggregate economic effects will be understated, since the spillover effects in county A will be missed. In the same context, analysis of a new basic activity in county A overestimates the induced effects, since, under traditional assumptions, all the nonbasic activity in the county will have been attributed solely to the personal income in county A. Once the nonbasic activity is correctly attributed to a combination of personal income in counties A and B, the induced effects per dollar of personal income will be reduced appropriately.

The empirical problem is to estimate $\gamma 1$ and $\gamma 2$ parameters. Multiple regression analysis could be used to estimate the equations specified above; however, the high degree of collinearity among the personal income series makes it very difficult to sort out the interaction effects. Another way of accounting for the effects of spatial interaction would be to aggregate the employment and income data over the counties within the region, since this would internalize intercounty trading within the region. The multiplier calculated for the region as a whole would be a reasonable estimate of the likely response of the induced sector to changes in basic activity. The problem with this method is that the total regional income and employment impacts must be allocated to the county (or subregional) level for analysis.

A third approach is to estimate the NBE/PI ratios recursively, starting with the simplest economies--the first-order places--and proceeding through the economic hierarchy. Assume the following pertain to the areas A and B described above:

	Area A	Area B
Personal Income ($000)	$5,000	$1,000
Nonbasic Employment, Sector j (trade, for example)	400	20

Using these data, γ_j^1 can be estimated as:

$$\gamma_j^1 = NBE_{j,B}/PI_B = 20/1000 = 0.02$$

Having estimated the first-order gamma for area B, the second-order gamma for Area A may be derived as follows:

$$NBE_{j,A}^1 = \gamma_j^1 \, (PI_A)$$

Assuming that γ_j^1 for A and B are equal,

$$NBE_{j,A}^1 = 0.02 \, (5000) = 100$$

Therefore, since total employment in sector j in county A is 400, second-order employment (NBE^2_j, A) must equal 300. That is, 100 of the 400 nonbasic employees in sector j of area A serve that area's first-order demands. The remaining workers are assumed to serve the second-order demands of both areas.

The estimate of nonbasic employment in sector j serving second-order needs is used in the following manner:

$$\gamma_j^2 = NBE^2_{j,A}/(PI_A + PI_B) = 300/6000 = 0.5$$

Thus, the nonbasic employment equation for sector j for area A would be represented as:

$$NBE_{j,A} = 0.02\ PI_A + 0.05\ (PI_A + PI_B)$$

The process outlined above can be extended throughout the hierarchy of higher-order demands and areas. If an area D served as a third-order trade center for both areas A and B, and served as a second- and third-order center for area C (note that a higher-order area can serve different functions for different areas), the 3 would be calculated as:

$$NBE^3_{j,D} = NBE_{j,D} - \gamma_j^1\ (PI_D) - \gamma_j^2\ (PI_D + PI_C) \text{ and}$$

$$\gamma_j^3 = NBE^3_{j,D}/(PI_A + PI_B + PI_C + PI_D)$$

Since area D serves the entire region, its third-order, nonbasic employment in sector j will respond to income changes in any of the four areas.

The first use of gammas to estimate nonbasic activity was in an economic/demographic model constructed by Mountain West Research for the Mid-Yellowstone Areawide Planning Organization, a five-county region in Montana. This was a crude attempt to account for market-area effects using a two-order hierarchy. Yellowstone County (Billings) was assumed to be a second-order county, with the other four counties forming its market area. First-order gammas were calculated on a county-by-county basis, with the average serving as the first-order demand estimate for Yellowstone County.[23]

The use of gammas, the concept of an economic hierarchy, and market areas were then incorporated into the Arizona Economic/Demographic Projection Model. The state was divided into first-, second-, and third-order counties, depending on size, and the relevant market areas delineated. The gammas were then

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[23] <u>Economic/Demographic Study of the Five County Mid-Yellowstone Areawide Planning Organization Region - Final Report</u> (Mountain West Research, Inc., 1977).

calculated on a county-by-county basis, beginning with the first order and proceeding through the hierarchy.[24]

The principal problem with both efforts was that the computed gammas were based on a very limited number of counties. For example, in Arizona, the four first-order counties formed the basis for estimating first-order demand for all 10 higher-order counties. Misclassification of a second-order county as a first-order county, or a unique characteristic in one of four counties, would significantly affect the results. Since the concept of the gammas is, by nature, an "average," it was desirable to minimize the empirical aberrations.

To increase the base of analysis, a study of 121 counties in the Northern Great Plains was conducted in 1977.[25] The purposes of the study were to identify the economic hierarchy for the region, determine the market areas served by each trade center, and estimate the appropriate gammas. The first step was to rank the counties according to an indicator of size and form clusters that corresponded to different levels in the economic hierarchy. Next, basic activity was identified and subtracted from the total employment of each sector. The gammas were calculated for all first-order places, and these were then averaged to estimate first-order demand. Nonbasic employment related to second-order demand was then estimated for all second-order places; the gammas were averaged and used to calculate third-order demand for counties of this level in the hierarchy.

Even the expanded sample did not provide a large enough number of observations to determine reasonable average relationships for demand in different-sized places. Of the 121 counties, 36 were eliminated because they were thought to have atypical economic structures. Twenty-seven of the remaining 85 were classified as first-order areas, 44 as second-order areas, and 14 as third-order counties. In addition to the problem related to the small number of observations, it also became apparent that a three-order hierarchy would not be reasonable for most areas of the country outside the Northern Great Plains. It was subsequently decided that additional research should pursue the following points:

1. Estimate the gamma relationships for a large number of observations

2. Define an economic hierarchy that would serve a larger, more complex geographic area

3. Investigate the existence of interregional differences and the implications of the differences to impact assessment applications.

The description of the most recent attempt to quantify the relationships is taken from research summarized in a paper titled "Spatial Interaction and the

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24 Description and Technical Description of the Economic/Demographic Projection Model (Arizona Office of Economic Planning and Development, 1977).

25 J. A. Chalmers et al., "Spatial Interaction in Sparsely Populated Regions: An Hierarchical Economic Base Approach," International Regional Science Review, 3 (1978), pp 75-92.

Economic Hierarchy in the Western United States," by Mountain West Research for the Bureau of Reclamation.[26]

The 17-state region in the western United States that is served by the Bureau of Reclamation was selected as the study area. Made up of 1054 counties, the area is diverse in terms of the character and distribution of its economic activity.* The database was obtained from the Bureau of Economic Analysis, Regional Economic Measurement Division, and included personal income, employment, and population figures for 1975. The level of disaggregation was the one-digit SIC breakdown; agriculture, mining, and Federal military sectors were excluded because of the nearly complete basic nature of those sectors for most counties.

The first two important research tasks were characterizing the economic hierarchy among the counties in the study area and determining the areas served by each market center. After ranking all counties in the sample according to personal income, which was found to be a better representation of market function than population, cluster analysis was used to distinguish six distinct hierarchical groups. Knowledge of the study area was used to adjust errors among the clusters for obvious classification.

The next step was to construct market-area maps for orders two through six. A map was not required for the first order, since all counties are assumed to be self-sufficient at this level. The trade centers at each level were identified on the appropriate map and the market area served by each center was delineated based on distance, the transportation network, and physical barriers between competing centers. The maps were then reviewed by the Bureau of Reclamation and State planning agencies and were adjusted based on the comments received.

An important step in the process is separating basic and nonbasic employment for each sector. In the Northern Great Plains study,[27] two-digit employment data, census information, and personal contacts with knowledgeable local sources were helpful in making the ad hoc distinction. Such an effort for the 988 areas in the Bureau of Reclamation's effort was clearly not practical. A method of indirect estimation was required and subsequently developed.

To some extent, all the commonly used indirect estimation techniques rely on the premise that induced activity should be distributed geographically in about the same proportion as the variables responsible for it. Location quotients and minimum requirement techniques are two frequently used methods. However, neither of these was suitable for the western United States sample, because neither can account for the effect of spatial interactions on induced activity.

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[26]E. J. Anderson, <u>Spatial Interaction and the Economic Hierarchy in the Western United States</u> (Bureau of Reclamation, Engineering and Research Center, 1981).

[27]"Spatial Interaction in Sparsely Populated Regions: An Hierarchical Economic Base Approach."

*It should be noted that the original 1,054 county sample was compressed to 988 by considering multicounty SMSA's as one county.

To deal with these issues, a method was devised based on four-digit county employment data obtained from the U.S. Army Construction Engineering Research Laboratory (CERL). The counties were segregated by order, which allowed an order-specific location quotient to be calculated for each sector and order. The industry mix problem of using location quotients was minimized since the calculations are done at the four-digit level. By grouping the counties according to an economic hierarchy, each county was compared to other counties with similar economic infrastructures.

A final step was needed before the gammas could be calculated. The sectoral four-digit basic and total-employment data were summed to the one-digit level. The ratios of basic-to-total employment for each sector and county were multiplied by the corresponding BEA employment. This was then subtracted from the total employment, which yielded the estimate of nonbasic employment that was used to calculate the gammas.

Despite the efforts to standardize the sample and eliminate large aberrations, some counties within each level of the hierarchy had calculated gammas that were substantially different (either higher or lower) than the average. The most probable cause for this is the existence of counties with inordinately large or small amounts of basic employment (relative to the regional averages) in certain sectors. It was reasoned that these counties would distort the true "average" qualities sought by the research, so they were excluded. The threshold for elimination of observations was plus or minus one standard deviation from the calculated mean. The order-specific averages were then reestimated with those observations eliminated.

Table 5 shows the implicit definition of the orders of the hierarchy in terms of the average personal income for the counties in each order. As shown by the standard deviations, the size of the counties in the smallest and largest order varies greatly, with relatively more stability in orders 2 through 5.

Table 6 presents the estimated gammas for nonbasic employment for each of seven sectors for the six orders in the hierarchy. The interpretation of the gammas is straightforward. Each coefficient shows the nonbasic employment response to a $1000 change in personal income (in constant 1972 dollars). Thus, in the services sector, for example, $1 million of personal income is expected to induce about 4.3 nonbasic jobs in the services sector in a first-order county. In a second-order county, which would be serving both its own first-order needs (4.3 jobs) and its own second-order needs (1.1 jobs), the nonbasic response to $1 million of personal income would be 5.4 jobs. Similarly, a second-order county serving as the market center for a smaller, first-order county would have 1.1 nonbasic jobs for each $1 million of personal income in the smaller county in its market area.

The cumulative gamma shows that the total response of nonbasic services employment to a $1 million change in personal income is about 8.5 jobs. However, only if the change in personal income occurred in a sixth-order county would the effect experienced by a single county be this large. Ordinarily, this cumulative effect is distributed among different counties at different levels in the hierarchy.

Table 5

Average Size of Counties for Each Order in the Hierarchy
(Millions of 1972 dollars)

Order	Personal income		Standard
	Average	Median	deviation
1	36.1	31.6	44.7
2	90.1	89.5	32.0
3	165.8	154.9	100.5
4	346.7	326.7	89.6
5	472.0	794.3	234.3
6	946.1	7,058.6	12,429.0

Source: Anderson, E. J., T. Beckhelm, J. A. Chalmers, B. Meinke, Spatial Interaction and the Economic Hierarchy in the Western United States, Mountain West Research, Inc., for the Bureau of Reclamation, Engineering and Research Center, Denver, Colo., 1981.

Table 6

Estimates of Gammas: Nonbasic Employment Response per $1,000 of Personal Income[1]
(988-county average)

Sector	1st order	2nd order	3rd order	4th order	5th order	6th order	Cumu-lative
Construction	0.00120	0.00036	0.00017	0.00024	0.00006	0.00019	0.00222
Manufacturing	0.00107	0.00063	0.00018	0.00017	0.00026	0.00081	0.00312
TCPU	0.00141	0.00035	0.00011	0.00014	0.00005	0.00020	0.00226
Trade	0.00612	0.00173	0.00075	0.00070	0.00063	0.00094	0.01087
FIRE	0.00106	0.00022	0.00005	0.00018	0.00009	0.00056	0.00216
Services	0.00433	0.00113	0.00034	0.00008	0.00055	0.00152	0.00855
Government	0.00974	0.00072	0.00117	-	0.00026	-	0.01189

1/ Income is measured in constant 1972 dollars.
Source: Anderson, E. J., T. Beckhelm, J. A. Chalmers, B. Meinke, Spatial Interaction and the Economic Hierarchy in the Western United States, Mountain West Research, Inc., for the Bureau of Reclamation, Engineering and Research Center, Denver, Colo., 1981.

Productivity Adjustment of the Gammas. The final consideration in determining nonbasic employment is to determine whether any changes can be anticipated in the relationship between nonbasic employment and personal income over the projection period. Technological change, increased capital intensity, and increased levels of human capital investment will all cause the output/labor ratios to rise. The implication is that while it is reasonable to expect a 1 percent increase in real personal income to generate an equal increase in real output (assuming the demand for nonbasic goods and services has an income elasticity of one), the increased demand for output is unlikely to increase the demand for employed persons by a corresponding amount because of secular increases in productivity. The adjustment made to the gammas is the other side of the real wage adjustment resulting from rising productivity. Real wages will be higher in the nonbasic sectors; however, since the same factors are responsible for the higher real wages, a greater amount of output can be produced with given labor inputs. Therefore, the gammas will decrease over time. As a result, the following adjustment is made. The gammas in year "t" are equal to the value of the coefficient in year "t^{-1}" times one minus the projected rate of productivity increase for the industry.

Summary. Economic assessment models have had two problems. Induced employment responses and, therefore, economic and demographic multipliers have been overestimated for market centers because the role of market-area personal income was not recognized in generating nonbasic employment.* Second, there was no way to trace the spread effects of economic impacts as they moved up through a region's central-place hierarchy. For example, the economic submodel of BREAM is now based on relationships that deal with both of these problems. Induced employment responses have been adjusted appropriately for market-area effects so that multipliers are measured more accurately. Third, because the hierarchy of counties has been defined and the economic linkages among them have been estimated, it is possible to use BREAM on multicounty areas and to study the spatial dispersion of impacts stemming from an action within the area.

Nonlabor Income

For many areas, a large part of personal income is not directly related to wages and salaries. As defined here, nonlabor income may be as much as one-half the total income of the region, although nationally it only represents about 23 percent. A major component of nonlabor income is transfer payments. Transfer payments are persons' receipts from Government and businesses for which no services are currently rendered. Social security receipts and other types of retirement benefits make up a large share of transfer payments. The other major category of nonlabor income is dividends, interest, and rent. This represents income received from things such as stocks, bonds, savings accounts, and property.

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*For example, if most of the trade sector employment in a regional center like Billings, MT, is attributed solely to personal income in Yellowstone County, the induced response in trade sector employment for a change in personal income in Yellowstone County would be grossly overestimated because, in fact, much of the trade-sector employment results from personal income occurring throughout the Billings market area.

Two other adjustments to labor income are needed to derive total personal income. The personal contributions for social insurance include the employee's share of the payment made to social security or other pension programs and represent a reduction in income received. The second adjustment accounts for the fact that some people work in one county but live in another. Since personal income by place of residence is needed, a residency adjustment is made.

The various nonlabor income components of personal income are projected as follows: the portion of transfer payments that is associated with retirement income (about 65 percent) is related to the size of the retirement population. This means that as the size of the retirement population increases in a county, retirement income is also projected to increase. Dividends, interest, rent, and the nonretirement component of transfer payments are related to the level of labor income in the county. Personal contributions for social insurance are handled similarly, and the residency adjustment is allowed to increase or decrease over time according to a rate of change supplied by the user.

Labor Market Submodel

The labor market submodel evaluates the consistency between the labor supply produced by the demographic submodel and the labor demand produced by the economic submodel. If there is an excess of jobs relative to the size of the labor force (that is, if the implicit unemployment rate falls below some prespecified lower bound), it is assumed that balance will be reestablished between the supply and demand for labor by immigration of labor force entrants. However, if there is an excess supply of labor (that is, if the implied unemployment rate exceeds the prespecified upper bound), it is assumed that outmigration will occur. When the unemployment rate is less than the upper bound but greater than the lower bound, there will be no employment-related migration, because the labor market is balanced and the projection process continues to the next year.

When the implied unemployment rate is outside the range established, the number of labor force migrants required to achieve labor market balance must be calculated. The labor force migrants are allocated to age and sex groups based on the industrial composition of the economy. The number of dependents associated with the labor force migrants is then calculated. Given the new level of population, the relationship between the supply and demand for labor has to be considered again. These iterations continue until the implied unemployment rate is brought within the user-specified bounds. Figure 5 shows the relationship of the labor market submodel. The specific quantitative steps used in the submodel are summarized below.

Labor Demand

The basis for the estimation of labor demand is the level of total employment produced by the economic model. Since this represents the number of jobs in the county rather than the number of persons employed there, an adjustment must be made to convert to a number of persons and place of

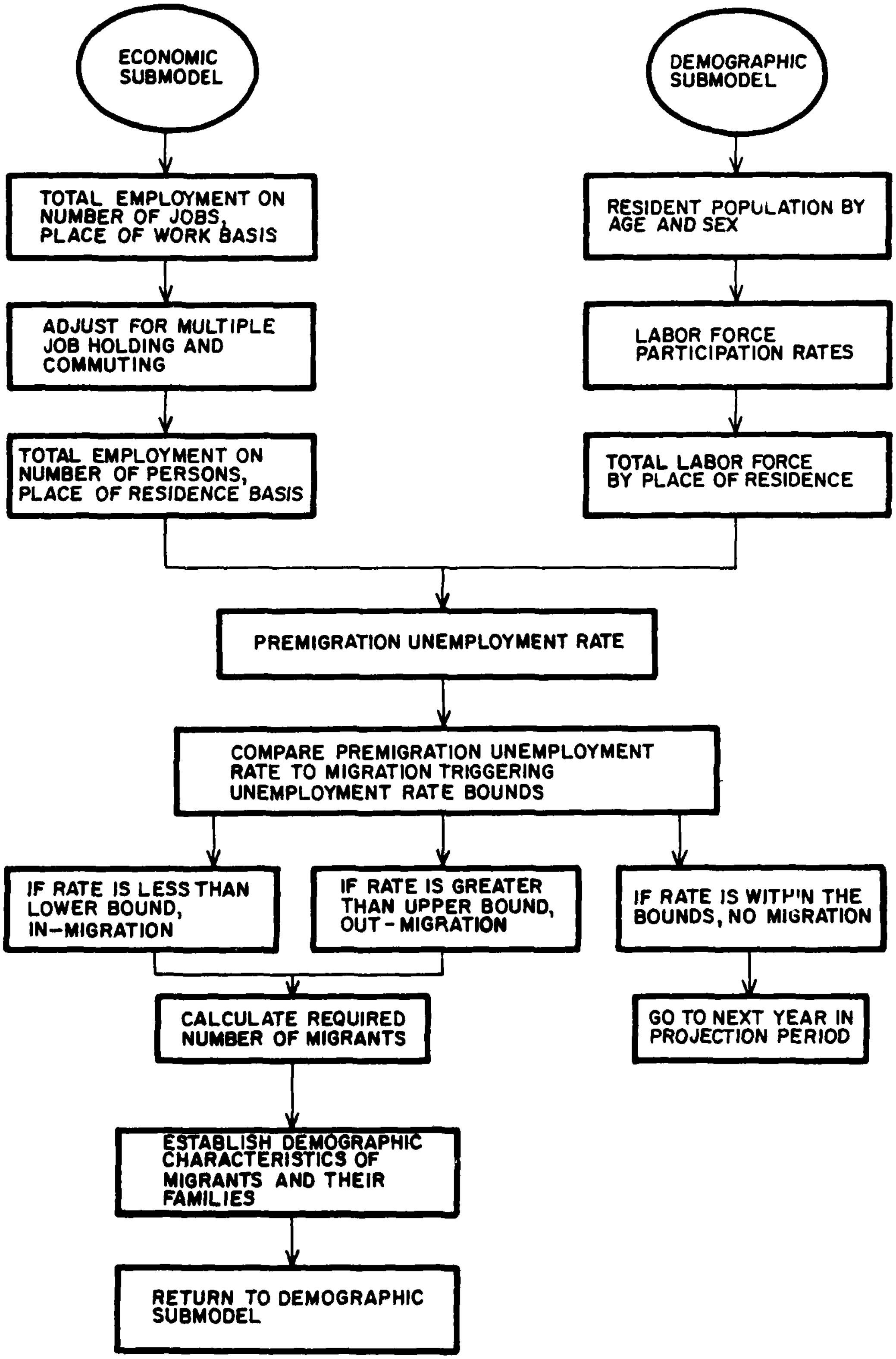

Figure 5. Labor market submodel of BREAM.

residence concept to ensure definitional consistency with the labor supply and population figures. An adjustment factor is calculated based on the population estimate for the first or subsequent forecast years that have been supplied by the user. Since the model benchmarks to published employment, population, and labor force estimates, these series often move inconsistently with respect to one another. The adjustment factor also provides a mechanism to calibrate the model to external data sources.

Labor Supply

The initial estimate of labor supply is calculated by multiplying the survived population in each age and sex cohort produced by the demographic submodel by the corresponding LFPR (labor force participation rate). The LFPR is the proportion of people of a cohort that are working or actively seeking work. Participation rates will vary among counties, and there will also be differences among cohorts. Base year participation rates may be adjusted during the forecast period to approximate the user's estimation of their probable future behavior. This is done by allowing the rates to converge to national projections published by the U.S. Department of Labor. This is an especially important adjustment for participation rates for certain cohorts, particularly prime age women and ethnic minorities, since their rates are changing rapidly. Therefore, historical rates will typically underestimate participation of some groups. Convergence to the national rates is a way to increase the ability of those groups to attain labor force status within the confines of the model's structure. After the labor force participation rates are applied, the total labor supply is found by summing across all the age and sex groups.

Employment-Related Migration

The unemployment rate implied by the labor supply and labor demand estimates is calculated as a means of estimating the amount of migration needed in a given year to balance labor supply and demand. This rate is then compared to the user-supplied lower and upper bounds. If it is higher than the upper bound, outmigration is assumed to occur. Conversely, if the unemployment rate is below the lower bound, inmigration is assumed.

The implied number of employed migrants is calculated by taking the difference between the desired labor force needed to achieve the lower- or upper-bound unemployment rate and the estimated labor force. If migration is indicated, the migrants are allocated to each of the 11 major industries according to the relative change in employment in each. Industry-specific data on age/sex characteristics of employed migrants are then applied to allocate the migrants to appropriate age and sex cohorts. The migrants are allocated to single-year-of-age cohorts by assuming a constant distribution within a 5-year cohort. Family characteristics are then determined to estimate the size and composition of the associated families.

Family Characteristics. The family characteristics component estimates the size and age distribution of dependents accompanying immigrants to (or leaving with outmigrants from) a particular county. These estimates are based on the following data inputs: a set of marriage probabilities, an age-of-wife matrix, and the survival and fertility rates.

The required marriage probabilities were obtained from the U.S. Bureau of the Census, U.S. Census of Population: 1970. However, these probabilities were available by single-year-of-age only between the ages of 14 and 30. For ages beyond 30, the marriage rates were given by a 5-year cohort. To convert these data to single-year-of-age, it is assumed that the 5-year cohort probability was identical for all members.

The age-of-wife matrix is a table of probabilities that gives the probability of a married man's wife being a certain number of years younger or older than himself. The submodel converts the relative ages to actual ages. For example, if there are 100 married males who are 24 years old, it is necessary to know how many 20-year-old wives will be associated with the 100 males. A value of 0.1 in the age-of-wife matrix indicates that 10 out of the 100 wives can be expected to be 4 years younger than their 24-year-old husbands, or in a actual terms, there will be 10 wives who are 20 years old.

The basic data needed to construct this table were obtained from the U.S. Census of Population: 1970 and are for the United States population. The age extremes (the wife being more than 10 years younger or more than 3 years older than her husband) were eliminated, and the probabilities associated with these extremes were distributed to the remaining ages.

The process of applying family characteristics (see Figure 6) is first to obtain the number of males, by single-year-of-age, for a particular subpopulation (1).* The males in each age cohort are then multiplied by the corresponding marriage probability group (2). This results in an estimate of married males by single-year-of-age (3). The age-of-wife matrix (4) is then used to calculate the expected ages of the wives (5). The number of children by single-year-of-age that can be associated with these married women is calculated by applying the fertility probability series (6). Each married female age cohort is multiplied by the fertility probabilities, beginning with the age group of the female cohort and continuing down 18 years or until the probability for 15-year-old females is reached, whichever comes first. This yields the number of children from infants to 18-year-olds associated with each female cohort. For example, the number of 40-year-old married females is multiplied by the 40-year-old fertility probability to estimate the number of infants associated with this age group. The number of 1-year-old children is the product of the number of 40-year-old females multiplied by the fertility probability for 39-year-old females. The number of 10-year-old-children associated with the 40-year-old females is the number of 40-year-old females multiplied by the 30-year-old fertility probability. The youngest mother is assumed to be 15, and the oldest a child can be and still be associated with the family is 18. Therefore, a 20-year-old married female can have children up to 5 years old. Since the oldest fertility rate is for 45-year-old females, the maximum age for females with children is 63 (45 + 18).

Once the number of children of each age associated with each female cohort is calculated, the number of children in each age group is obtained by summing over the married female cohorts. The total number of children in each group is divided into males and females by applying the ratio of male to female births (7), thus yielding the number of children by sex and single-

*The numbers in parentheses are similarly labeled in Figure 6.

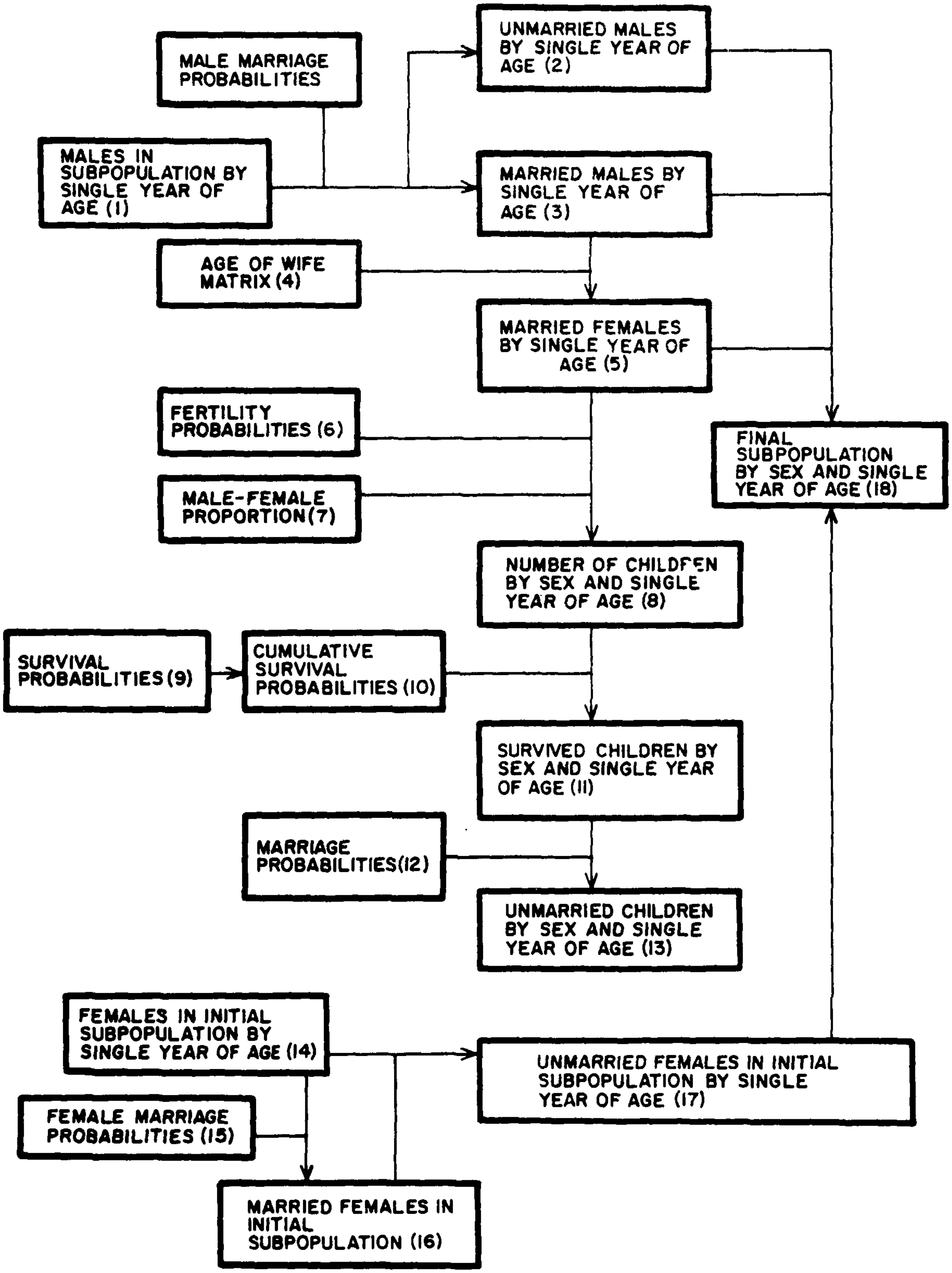

Figure 6. Family characteristics submodel of BREAM.

year-of-age (8). The age- and sex-specific cumulative survival rates (10) are then applied to the number of children in each age and sex cohort to estimate the number in each group expected to survive to their present age (11). A final adjustment is to subtract any children that are married since the married children are assumed not to migrate with their family. This is done by applying the marriage probabilities to the 15- through 18-year-old male and females (12). This yields the number of married children (13).

Since the submodel generates an estimate of married females (5), some of whom may be included in the initial subpopulation, an adjustment must be made to eliminate the double-counting. Marriage probabilities (15) are applied to the females in the initial subpopulation (14), yielding the number married (16), which is then removed from the initial subpopulation (17). The final step is to add the number of married females and children to the initial subpopulation input step (2)+(3)+(5)+(13)+(17) = (18).

Community Allocation Submodel

The community allocation submodel is used to allocate the county-level population projections of the model to specific communities in the study area. The allocation procedure addresses each component of population change individually. Population change from the previous year is equal to the natural increase (births minus deaths) plus retirement migration plus employment-related migration. Employment migration can be further subdivided into mover construction workers and all other employment migration components. Each component is allocated according to one of three community distributions generated by the model or according to a user-specified distribution.

The first distribution generated by the model is a fixed distribution equal to the community's share of the county's population for the first forecast year. A second option is a variable distribution equal to the community's share of the county's population for the year prior to the projection year (i.e., the distribution in 1985 would determine the distribution in 1986). A third option is based on the growth experience of each community between the last census year and the first forecast year relative to the county's overall growth experience. For this option, the allocation factors are calculated by summing the changes in population over all the communities and then estimating the relative share of the county population change experienced by each community. Mover construction workers and their dependents are then allocated on a project-by-project basis according to the allocation assumptions calculated in the construction worker submodel. Once each component of population change has been allocated, the total change for each community is summed and added to the previous year's community population, yielding an estimate of the current year's population.

Two additional calculations are then made in the community allocation submodel. First, the total number of housing units by community is calculated in a three-step process. The user supplies the number of households associated with each mover construction worker. The average household sizes for the population 60 years of age and older and for the remainder of the population are also model inputs. An average change factor can also be applied to each household size parameter to allow for secular trends in household size. The total number of households in the county is then

allocated to the communities based on the distribution of population. Second, the number of children in the school-age cohorts are allocated to each community in the study area based on the community distribution of the population. Three school-age cohorts corresponding to elementary, junior high, and high school groups are included in BREAM. Figure 7 summarizes the overall structure of the community allocation submodel.

Model Strengths and Limitations

The previous sections have presented a detailed discussion of the BREAM submodels and the theories on which they are based. Historically, one failure of this type of description has been to cast a model in such a favorable light that readers were misled about the applicability of the procedures. With that in mind, this section will discuss some of the more subtle aspects of the model that affect the manner in which impact assessments are completed. It is not intended to be a defense of the methodology, but rather as an explanation of some peculiarities of which potential users should be aware.

Model Strengths

A realistic appraisal of BREAM's conceptual framework reveals appealing aspects. BREAM provides a mechanical, empirically based method of producing consistent projects of population, employment, and income, and therefore, is a way to evaluate the objective results produced by different assumptions about instrumental economic and demographic variables. The model's structure employs a relatively detailed demographic structure, a straightforward economic framework, and a specific accounting for many of the real work variables that are most subject to change (vital rates, migration, labor force participation, and the spatial interaction among different-sized economies). The result is a tool that can be used for impact assessment in different ways in places with a variety of economic and demographic structures.

However, the model does have limitations that affect how assessment projects must be approached. It is the more subtle aspects of the model that dictate the steps of a given assessment. The following discussion is designed to acquaint the potential user with some of BREAM's features and present the appropriate techniques to capitalize on the model's strengths and limitations.

Pragmatic Characteristics

First, the user should be familiar with the overall theoretical framework of the model, particularly how the submodels interact. Second, the user must have knowledge of the local impact or planning area. One explicit purpose of BREAM, in addition to its function as a planning and assessment tool, is to provide a structured format for collecting relevant socioeconomic data and for analyzing relationships to be used in effective impact planning. Used correctly, BREAM is an important organizational tool that allows the user to better understand the area being studied.

Limitations

There are limitations of the model which affect how impacts are assessed. These aspects may be considered inherent weaknesses, although they do not

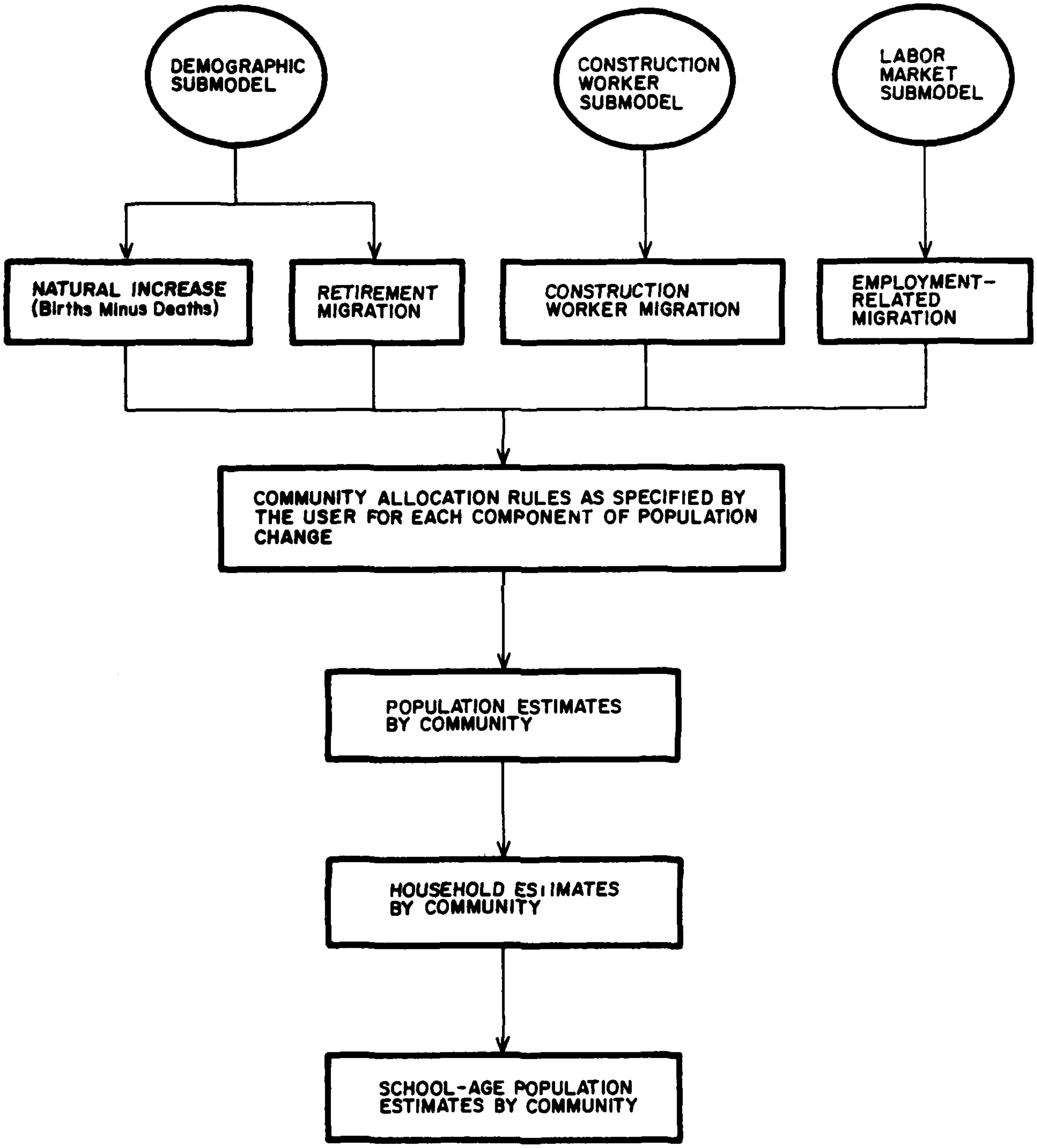

Figure 7. Community allocation submodel of BREAM.

necessarily detract from the model's stated purposes. The user must be cognizant of the functions that BREAM cannot effectively fulfill. Awareness of these limitations will help in interpreting the model's output realistically.

Leads and Lags. A problem may be encountered using BREAM in an assessment or planning study in which a large basic employment change occurs over a short period of time. The model's structure presupposes that the exogenous changes in basic employment and induced effects occur concurrently. Because the model deals with "annual averages," it is difficult for the methodology to sort out peak employment on any basis other than an annual one. Similarly, the induced changes do not appear until the basic employment has been introduced. Unfortunately, real world situations may not correspond to these assumptions. Peak employment may be seasonal, and the effects of such a pattern would not be well represented by a series of average annual data. Also, induced employment may not be concurrent with the basic employment stimulus. There is evidence that induced construction activity may anticipate project initiation, and that induced employment activity may have a threshold limit which dictates internal changes in labor market structure (changes in working hours or skill classes) prior to large adjustment via changed unemployment or migration. The result is that the implied multipliers may either overestimate the actual induced effects, or incorrectly time the anticipated annual changes. This has been a problem in very small areas that have experienced a large basic employment change that was relatively short-lived.

Interindustry Purchases. The economic submodel of BREAM has an economic base foundation and, as such, has no explicit consideration of interindustry purchases. This may or may not be a problem, depending on the extent of local purchases of intermediate goods in an area. If the indirect basic activity related to a project is substantial, the BREAM data must be supplemented with some estimate of those effects. A formal input-output model based on primary data is not likely to be a cost-effective alternative. Nonetheless, existing data on interindustry transactions must be reviewed carefully to account for important forward or backward linkages and to identify any indirect basic employment associated with the proposed project.[28] These data must then be included with the direct basic employment inputs to BREAM.

Labor Force Participation. As BREAM is currently configured, the labor market submodel evaluates the consistency of labor supply projections with the labor demand implied by the area's projected economic activity. Labor market imbalances are assumed to initiate adjustments, with the principal mechanism being employment-related migration. Accordingly, the model ignores any structural changes that may occur in response to labor market imbalance. A primary change that is not explicitly accounted for is the likelihood that labor force participation rates may fluctuate with economic opportunity. Although the explicit mechanism of BREAM may work well for skilled occupations that depend substantially on imported labor under most development alternatives, the responsiveness (of local labor markets) under these circumstances is probably understated. Ideally, labor force participation rates should be treated endo-

[28] An acceptable method to estimate the indirect basic requirements of a small area with sparse interindustry purchase data is described in J. A. Chalmers and E. J. Anderson, Economic/Demographic Assessment Manual (1977).

genously as a function of both demographic and economic characteristics. Unfortunately, not enough is yet known to make participation rates endogenous, particularly for rural areas in which a significant amount of the economic expansion is occurring. Therefore, the user should closely examine the labor force participation data being used for a BREAM run and evaluate the probable effects of the proposed action on those rates.

Application to Large Urban Areas. One shortcoming of BREAM has been identified in applications to large urban areas. The relatively simple (as opposed to a complex multisector, input-output model) economic base framework does not readily lend itself to analysis of complex economies, especially if a proposed plan is a small contribution to total economic activity. Also, the labor market imbalance issue described above is particularly germane to large urban areas, and the explicit evaluation of construction worker behavior can be meaningless for areas with thousands of existing construction employees. Although BREAM has been used for analysis in large urban areas, its comparative advantage lies in its ability to assess changes in smaller regions.

Wages, Productivity, and the Gammas. The final qualifying remarks about BREAM concern the gammas and the associated variables that present real-wage and productivity adjustments. The concept of the gammas is appealing: there is a quantifiable relationship between income and induced economic activity. This relationship is easily computed at one point in time. As the model is currently configured, the gammas and real wages are adjusted for forecast changes in productivity. However, these adjustments may not accurately reflect the short-run pattern of wages and employment for some sectors in a given area. The probable extent of the differences between the model's forecast of the changes in gammas and those that actually occur is unknown, although the differences should be insignificant.

Summary

It is important to reiterate that BREAM is a simulation model, the principal function of which is to allow the user to systematically examine the economic/demographic implications of explicit assumptions about an area's future. As such, the model's principal role is not to predict the future, but rather to allow the implications of different assumptions for the future to be evaluated. It is then the user's responsibility (with public input as appropriate) to determine which assumptions provide the most sensible foundation for planning and assessment activities. BREAM then serves as an operational tool that can be used to trace out the explicit economic and demographic implications of the assumptions in an efficient and mutually consistent fashion.

3 REGIONAL INDUSTRIAL MULTIPLIER SYSTEM (RIMS)

Introduction

The Regional Industrial Multiplier System (RIMS) is a set of procedures that generates input-output (I-O) type industrial multipliers for any county or multi-county area in the United States. The methodology described in this chapter is the same as was developed at the Bureau of Economic Analysis (BEA) and then improved and extended by Regional Analytics.[29]

RIMS produces I-O type multipliers. That is, they relate changes in regional gross output, income, or employment to changes in a specific-industry final demand for the region. They are used in regional economic impact analysis just like the multipliers from any regional input-output model. Given an initial change in exports, government expenditures, or any other component of final demand, these multipliers can estimate the change in total gross output, income, or employment. In addition, RIMS estimates the industrial distribution of the gross output, income, and employment changes, so that an analyst may also evaluate the distributional aspects of regional economic impacts.

The multiplier-estimating procedure follows from the decomposition of the multiplier into two components: (1) the direct component, and (2) the indirect-induced component. The direct component is estimated by "regionalizing" a column from the most recent National Input-Output model, using four-digit Standard Industrial Classification (SIC) location quotients computed from the most recent County Business Patterns (CBP) employment data.[30] The indirect-induced component is based on its relationship with the direct component, taking into account a region's economic size and industrial structure.

Using these multipliers has several advantages. Being I-O type multipliers, they provide results which are specific to a particular regional industry. Furthermore, because of the relatively disaggregated sectoring plan (i.e., about 500 industrial sectors), analysis may be performed at a detailed-industry level, thus avoiding the errors which occur when different industries are combined. These multipliers also offer a consistent set of assumptions across regions, making comparisons between regions more meaningful than would be the case if results were based on different procedures and conventions.

The rest of this chapter discusses input-output analysis in general, the RIMS procedures in particular, and the databases needed to implement RIMS.

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[29] Industry-Specific Gross Output Multipliers for BEA Economic Areas (Bureau of Economic Analysis [BEA], U.S. Department of Commerce, January 1977); R. L. Drake, CERL-RIMS: Methodology and Documentation (Regional Analytics, 1982).

[30] The Detailed Input-Output Structure of the U.S. Economy: 1972 Volumes I and II (U.S. Department of Commerce, 1979); County Business Patterns: 1980 (U.S. Department of Commerce, 1982).

Input-Output Analysis

Even though Wassily Leontief is largely responsible for the modern development of input-output analysis, emphasis on interindustry relationships can be traced as far back as 1758 in Francois Quesnay's Tableau Economique and to the development of Leon Walras' general equilibrium model of the 1870.[31] I-O tables, which form the heart of interindustry analysis, have been compiled for many countries, including the USSR. In the United States, I-O tables for both national and subnational (i.e., counties, states, etc.) levels are available. National I-O tables for the United States are constructed periodically by the U.S. Department of Commerce; the most recent one available is for 1972.

Over the past 50 years, input-output economics has become well-established and is very popular among regional analysts. In large part, this popularity is due to the flexibility of the model and the "richness" of its results. This is especially appealing in a field where the problems of data availability are great and where theoretical constructs are simple. And, from a theoretical point of view, I-O analysis offers a general equilibrium approach to regional issues, rather than the partial equilibrium analysis of its competitors (i.e., economic-base and regional econometric models).[32]

Input-Output Accounts

Input-output models generally fulfill two functions: (1) a set of income accounts which shows the relationship between industries and between inputs and outputs, and (2) a useful analytic tool when certain economic assumptions are made. The following discussion concentrates on the accounting framework of I-O analysis.

Input-output analysis explicitly considers all of the interrelationships between an economy's industrial sectors. This means that the manufacture of goods and services is "traced through" all the steps of production, not just the creation of "new wealth." In terms of sales, input-output accounts partition the sales of each industrial sector according to intermediate and final uses. Intermediate uses are the sales from one sector to another, and represent the goods and services consumed during the production of other commodities. Final uses are the sales to the end users of each industry's commodities (e.g., consumer consumption, government purchases, investment, and exports). For regional input-output accounts, exports include both sales to other parts of the country and to foreign demand. Similarly, government purchases include local, State, and Federal government expenditures.

Mathematically, each industrial sector of, for instance, a regional economy, has a typical distribution of sales;

$$\sum_{j=1}^{s} X_{ij} + \sum_{k=1}^{t} Y_{ik} = X_i \qquad \text{[Eq 8]}$$

[31] H. W. Richardson, Input-Output and Regional Economics (Weidenfeld and Nicolson: London, 1972), p 7.

[32] Input-Output and Regional Economics, p 1.

where

X_{ij} is a sale from regional industry i to regional industry j

Y_{ik} is a sale from regional industry i to final demand sector k

X_i is the total of all sales for regional industry i

s is the number of regional industries

t is the number of final demand sectors.

Notice that Eq 8 is just an algebraic representation of a typical industry's sales, either to intermediate users (other industries), or to final users (consumers, exports, etc.). A similar equation can be written that represents the payments for various productive requirements of a typical regional industry; e.g.,

$$\sum_{i=1}^{s} X_{ij} + \sum_{\ell=1}^{u} V_{\ell j} = X_j \qquad \text{[Eq 9]}$$

where:

$V_{\ell j}$ is the payment to value-added sector ℓ (i.e., labor, rent, profits, etc.) by industry j

X_j is the total value of input requirements for industry j

u is the number of value-added sectors.

Note again that Eq 9 is an accounting of a typical industry's payments, either for intermediate inputs (other industries) or for primary inputs (labor, rents, profits, etc.).

When all of the industries' sales and input structures have been specified, they can be combined in the form of a matrix called the transactions table. A transaction table is an accounting framework which shows the production and consumption of all commodities produced within an economy. The transaction table can be illustrated by a matrix portioned into three quadrants: a processing sector, a final-demand sector, and a payments sector.* A hypothetical transactions table is shown in Figure 8 (Input-Ouput Table). The northwest quadrant of the transactions table is called the processing sector, because it shows the production and consumption of goods and services for each of the industries within an economy. The processing sector is a square matrix (i.e., having an equal number of rows and columns); each row represents an industry selling its commodities to all of the economy's industries, and each column represents an industry purchasing its productive requirements from the

*A fourth quadrant of the transactions table, where the payments and final demand sectors intersect, is usually omitted.

		PRODUCERS									FINAL DEMAND (GNP)				GROSS OUTPUT
		Agriculture	Mining	Construction	Manufacturing	Transportation	Trade	Finance	Services	Other	Personal consumption expenditures	Gross private domestic investment	Net exports	Government purchases	
PRODUCERS	Agriculture														
	Mining														
	Constructure														
	Manufacturing											FINAL DEMAND			
	Transportation			PROCESSING SECTOR								SECTOR			
	Trade														
	Finance														
	Services														
	Other														
VALUE ADDED (Charges against GNP)	Compensation of employees														
	Profit-type income* net interest & capital consumption allowances							PAYMENTS							
	Indirect business taxes							SECTOR							
GROSS INPUT															

*Consists of proprietors income, rental income of persons, corporate profits, and business transfer payments, less subsidies, etc

Figure 8. Input-output table.

economy's industrial sectors. A typical element in the processing sector shows a sale of a producing industry (row) to a purchasing industry (column). For example, one element in the processing sector might represent a sale of agricultural products to firms in the food-processing industry.

The southwest quadrant is called the payments sector (or sometimes the value-added sector), and it accounts for the compensation paid by the economy's industries for the services rendered by the owners of labor, capital, land, and other primary inputs. Besides imports, the payments sector includes industrial outlays for wages and salaries, taxes, depreciation allowances, rents, and profits.

The northeast quadrant (final demand) sector shows purchases by the final users of the economy (e.g., personal consumption, government purchases, investment, and exports). By way of comparison, the final demand sector of a transaction table is an industry-specific disaggregation of the Keynesian income-consumption accounting framework. That is, on a simple level, income equals the sum of consumption, investment, government purchases, and net exports.

Input-Output Model

Assumptions. Given certain economic assumptions about the nature of an economy's productive processes, the input-output accounts can be used to derive an analytic tool for measuring the impacts associated with autonomous changes on the economy's output, employment, and income. There are three basic assumptions of input-output modeling:[33]

1. Each commodity (or group of commodities) is produced in a single industry or sector of the economy, and only one method is used to produce each commodity (or group of commodities). Consequently, each industry or sector is assumed to produce a single and primary output.

2. The quantity of inputs purchased by each industry is a function of the level of that sector's production. It is also commonly assumed that the relationships between inputs and outputs are linear (i.e., homogeneous of degree one, in mathematical jargon). This also means that economies and diseconomies of scale as well as substitution possibilities among inputs are not possible.

3. The total effect of carrying on several types of production is the sum of the separate effects.

This simply says that the input-output model is based on the premises that all economic activities and their interrelationships can be expressed as a set of simple input functions, and that these input functions remain constant during the period of time for which the model is applied.

Direct, Indirect, and Induced Effects. Besides the transactions table, an input-output model consists of several other matrices. Each matrix

[33] H. B. Chenery and P. G. Clark, Interindustry Economics (John Wiley and Sons, Inc.: London, 1959), pp 33-4.

represents differing levels of economic impacts that result from an economy moving from one position of equilibrium to another because of an autonomous change.

First, since production processes are assumed to be linear, each input must be purchased in a fixed proportion, in relation to the other productive requirements, to yield one unit of output.* Thus, the coefficient specifying the amount of input i needed to produce a unit of commodity j is denoted as a_{ij} and is computed as

$$a_{ij} = \frac{X_{ij}}{X_j} \qquad \text{[Eq 10]}$$

where:

a_{ij} is the amount of commodity i used per unit of good j produced

X_{ij} is a sale from industry i to industry j

X_j is the total sales for industry j.

If one has all the input requirements specified in terms of a unit of output for a commodity, then the basic "recipe" needed to make that product is determined. In other words, if an extra unit of industry j's output is needed to meet consumer demands, then a_{ij} worth of product i will be required directly from industry i.

Notice that Eq 10 may be algebraically substituted into Eq 8 and rewritten as

$$\sum_{j=1}^{s} a_{ij}X_j + \sum_{k=1}^{t} Y_{ik} = X_i \qquad \text{[Eq 11]}$$

where:

a_{ij} is the amount of commodity i used per unit of good j produced

X_j is the output of industry j

Y_{ik} is a sale from industry i to final demand sector k

X_i is the output of industry i

s is the number of industrial sectors

t is the number of final demand sectors.

*The most commonly used unit of output is a monetary value, such as a dollar. Quantity measures are used in I-O tables for the USSR.

If Eq 11 is compiled for each of the economy's industries, then all of the equations, considered as a whole, represent the economy's input-output structure. This system of simultaneous equations can be expressed in matrix notation as:

$$AX + Y = X \qquad \text{[Eq 12]}$$

where:

A is a square matrix of input requirements with a typical element, a_{ij}, and has s rows and s columns

X is a column vector of output values with a typical element, X_i, and has s rows,

Y is a rectangular matrix of final demands, with a typical element, Y_{ik}, and has s rows and t columns.

The A matrix (Eq 12) is interesting because it defines the technical interrelationships between each of the economy's industrial sectors. In other words, the A matrix specifies the economy's technological structure. The matrix of technical coefficients (i.e., the A matrix) is often referred to as the "direct requirements" table, because it specifies and estimates the quantity of those goods and services that will be directly required as a result of some autonomous stimulus (e.g., exports or government purchases). Stated a little differently, the direct requirements table measures the direct effect (in terms of output) on each of the economy's industries that results from an exogenous stimulus.

Second, with the aid of matrix algebra, the simultaneous equation system of the economy (Eq 12) can be solved for each industry's output in terms of its final demands; i.e.,

$$X = (I-A)^{-1} Y = BY \qquad \text{[Eq 13]}$$

where:

X is the column vector of output values for each of the economy's industries

I is an identity matrix (i.e., 1's down the main diagonal and 0's everywhere else)

A is the matrix of technical coefficients (note that I has the same dimensions as A)

Y is a column vector of final demand changes

B is the "Leontief inverse" matrix, $(I-A)^{-1}$, with typical element b_{ij}.

The Leontief inverse matrix is also called the "direct and indirect requirements" matrix. It estimates the industrial purchases that are directly needed not only to sell an extra unit of an industry's output to a final user, but also those purchases needed to satisfy the direct changes. These extra purchases by the economy's industries reflect the adjustments in productive requirements and inventory changes by firms in response to changes in demand for their products.

Third, the household consumption vector of final demand and the labor payments vector of value added are frequently augmented to the technical matrix. The resulting system of equations is solved as before for the outputs of each of the economy's industrial sectors, excluding household consumption and labor, in terms of final demand, including household consumption. The addition of households to the technical matrix and the resulting augmented Leontief inverse matrix incorporates the induced effect of changing income and consumption by the economy's workers and their dependents to the direct and indirect effects of final demand changes. The augmented Leontief inverse matrix is referred to as the "direct, indirect, and induced requirements" matrix because each of its elements represents the direct, indirect, and induced purchases by one industry from another in order to satisfy one additional unit of final demand sales for the producing sector. Models in which households are not augmented to the technical matrix are called "open" input-output models. When the households are included, the input-output model is "closed" or closed with respect to households.

Multipliers.[34] The Leontief inverse matrix, whether augmented to include households or not, forms the basis for multiplier analysis within the input-output model. These multipliers probably make the Leontief inverse matrix the most useful of any of the input-output matrices, at least for economic impact analysis. Input-output multipliers "come in many colors," and care should be exercised with their use and interpretation. For example, multipliers that are derived from a Leontief inverse matrix not augmented by households are called Type I multipliers. This classification identifies them as not including the induced effects of household income and consumption. When the households are included, the multipliers are classified as Type II input-output multipliers. The discussion here will concentrate on Type II multipliers, but the extension to Type I multipliers is quite simple.

Another way to classify input-output multipliers is according to their purpose and use. For example, there are tax revenue multipliers, government revenue mulipliers, investment multipliers, etc. Multipliers can be computed for almost any type of activity as long as the activity can be expressed in terms of "per unit of output" for each of the economy's industrial sectors. Three of the most commonly used input-output multipliers will be described here: output, income, and employment.

Deriving multipliers within the input-output framework is a straightforward exercise. For example, the total (direct, indirect, and induced) output change within an economy due to a unit change in final demand for a

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[34]There are numerous sources for input-output multiplier computations and analysis; a very good source is H. W. Richardson, Input-Output and Regional Economics, Weidenfield and Nicolson: London (1972), pp 31-52.

particular industry's product is the sum of the column coefficients (excluding the household element) for that industry from the augmented Leontief inverse matrix, e.g.,

$$\Psi_{qj} = \sum_{i=1}^{s} c_{ij} \qquad \text{[Eq 14]}$$

where:

Ψ_{qj} is the total output multiplier for industry j

c_{ij} is the typical element of the augmented Leontief inverse matrix representing the direct, indirect, and induced purchases by industry i due to a unit change in industry j's output

q identifies the multiplier as an output multiplier

s is the number of industrial sectors.

Other types of multipliers are computed by weighing the components of the output multipliers (i.e., c_{ij}) of Eq 14 with industry-specific per unit of output factors. For income multipliers, the factors represent the income paid to workers per unit of output; i.e.,

$$\Psi_{yj} = \sum_{i=1}^{s} c_{ij}\, y_i \qquad \text{[Eq 15]}$$

where:

Ψ_{yj} is the total income multiplier for industry j

c_{ij} is the typical element of the augmented Leontief inverse matrix

y_i is income per unit of output for industry i

y identifies the multiplier as an income multipler

s is the number of industrial sectors.

Similarly, employment multipliers are calculated by weighting the components of the output multipliers of Eq 14 with the industry-specific employee per unit of output ratios; e.g.,

$$\Psi_{ej} = \sum_{i=1}^{s} c_{ij}\, \rho_i \qquad \text{[Eq 16]}$$

where:

Ψ_{ej} is the total employment multiplier for industry j

c_{ij} is the typical element of the augmented Leontief inverse matrix

ρ_{ij} is the employee per unit of output ratio for industry i

ρ identifies the multiplier as an employment multiplier

s is the number of industries.

Conceptual Problems with Input-Output Models

Input-output models provide a great deal of detail on the economic transactions that take place within a local economy and offer some understanding as to how impacts originating in one sector are transmitted throughout the economy. The major conceptual problems of this model stem from the assumptions on which the model's structure is derived.

Growth or economic impact analysis is modeled by linear production functions for each industry. Linearity imposes nonsubstitutability constraints for both factor inputs and outputs. Any changes introduced into the system must consequently cause a proportionate increase or decrease in existing patterns. Linearity also implies the absence of scale economies, which runs counter to important theoretical arguments for the existence of cities, namely agglomeration and urbanization economies.

Technical coefficients of the interindustry transactions matrix are assumed to be constant, thus making it difficult for technological change and productivity adjustments to be represented in the system. If these coefficients are taken to be the ratio of the value of transactions to total output, then relative prices and wages must be assumed constant, or changes in trading patterns (substitution among inputs) will result in changed coefficients.

Because of the assumptions used to develop the input-output model, these models are only appropriate for analyzing short-run problems. As one's time horizon expands, the possibility of input substitution, technological change, etc., would require revising the input-output structure, and at a minimum, reestimating the technical coefficients.

The models are also static, so it is hard to incorporate dynamic features in the model. Housing purchases by consumers and complex behavioral relationships governing capital formation by businesses are typically calculated outside of the model, and forecasted values are introduced as exogenous components of final demand. The exogenous components may then be included as part of an impact analysis by incorporating these final demand columns into the interindustry transactions matrix and taking the inverse of the augmented matrix.

Changes in regional structure, such as the introduction of a new industry, also present a problem in the input-output model. It is the equivalent of adding a row and a column to the input-output table and recalculating a number

of new coefficients. If the new industry is introduced sometime after the estimation of the table, serious difficulties may be introduced by the technique used to update the other coefficients if a new survey is to be avoided.

Technical Problems with Input-Output Models

There are two distinct approaches to regional input-output models and, consequently, two sets of technical problems: input-output tables may be constructed either by census or survey methods, or by "borrowing" coefficients from other input-output tables.

If a survey will be done rather than a full census, the first problem encountered is the sampling problem.[35] The sampling problem is how to determine the total number of firms to be sampled and the number of firms per industry. Many researchers either formulate a rule to sample the largest employers until the budget is exhausted, or simply take a random sample of all firms. If the task is to estimate industry production functions, then the intra-industry variance in proportion of inputs used should be the basis for a sampling rule. For example, if all the firms in industry A have identical production functions, while the firms in industry B exhibit quite a bit of variance in the amounts of inputs used, more firms in B than in A must be sampled to minimize the total variation in the estimated production functions.*

Once the sample is obtained, firms must somehow be aggregated into industries, and current purchases must be distinguished from investment. If there is a great deal of diversity among firms that produce similar products or if there are many multiproduct firms, the problem of aggregating firms into industries may be considerable. If one views each firm as an industry, then the advantage of a model in assembling and collecting data into more meaningful categories is lost. On the other hand, too much aggregation will result in estimated production functions that have little correspondence with the economy that they are supposed to describe, and will also produce biased forecasts. The aggregation process depends largely on the researcher's judgment, and few studies speculate on the errors that might be introduced by the aggregation scheme.

When completing the survey, firms are requested to list the materials purchased for production. A plant manager or executive officer will frequently list purchases from their capital account. It is then up to the researcher to carefully separate current from investment purchases. To the extent that the two accounts overlap, biases will be introduced into the model.

Finally, after assembling the data, the input-output table must balance; that is, sales must equal purchases if the table is to have any validity. An input-output table based on a sample will generally not balance at first. The

[35]For a complete description of the sampling problems, see G. Gerking, "Input-Output as a Simple Econometric Model," Review of Economics and Statistics, Vol 58 (1970), pp 35-47.

*In fact, if all firms in industry A had identical production functions, one would need to sample only one firm.

reconciliation process (that is, the process of equating rows and columns) is not based on generally accepted procedures. Instead, it is based on individual judgment, often in conjunction with industry experts. This implies that two researchers with exactly the same data may obtain two different input-output tables, and there is no information about whether these differences would be nonmarginal.

Input-output tables constructed from sample data are very costly and cannot be completed quickly. For example, Norman Glickman reports that the 500-sector 1958 Philadelphia Input-Output study cost about $250,000 and took 5 years to complete.[36] Walter Isard and T. Langford indicate that the 1958 Philadephia input-output table was expensive to carry out and experienced research personnel were difficult to maintain.[37] As a result, few survey-based input-output projects are being done.

In sum, input-output models are most appropriate for short-run forecasting problems where a lot of detail is needed or where the initial final demand change occurs in one or just a few of the industrial sectors. Although the detailed information needed to construct survey-based input-output models can be quite costly to obtain, various nonsurvey methods (especially the location quotient techniques)[38] have made computing input-output multipliers convenient and inexpensive, even for the smallest geographic areas. As far as aggregate impact estimation is concerned, a number of studies have shown the mathematical identity of input-output and economic base multipliers.[39] Thus, when evaluating the economic impact of a project in which many or all industrial sectors of the economy are initially affected by final demand changes, the economic base model may be a better choice. This may be due largely to the uncertainty of the expenditure patterns generated by a project. However, one of the best arguments for using input-output models is probably their emphasis on general equilibrium analysis rather than partial equilibrium changes.[40]

RIMS Procedures

RIMS Methodology

The heart of the RIMS procedure is the independent estimation of the multiplier's indirect component. The I-O multiplier relates total gross output to an initial final demand change for a given industry. The multiplier can be seen to be made up of three components: the initial effects, the direct

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[36] R. J. Glickman, Econometric Analysis of Regional Systems (Academic Press, 1977), p 35.

[37] W. Isard, T. W. Longford, and E. Romanoff, The Philadelphia Review Input-Output Study (Regional Science Research Institute, Mines, 1967).

[38] For a review of nonsurvey input-output methods, see W. Schaffer and K. Chu, "Nonsurvey Techniques for Constructing Regional Interindustry Models," Papers of the Regional Science Association, Vol 23 (1969), pp 83-101.

[39] For a proof of this see R. B. Billings, "The Mathematical Identity of the Multipliers Derived from the Economic Base Model and the Input-Output Model," Journal of Regional Science, Vol 9 (1969), pp 471-3.

[40] Input-Output and Regional Economics, p 1.

effect, and the indirect effect. The initial effect, always equal to 1.0, represents the initial final demand change. The direct effect is the sum of the first round of interindustry sales. It is simply the sum of the regional direct requirements for inputs for the industry experiencing the initial final demand change. The indirect effect is the sum of all other rounds of expenditures.

Consider an example of a manufacturing establishment, with an I-O multiplier of 2.5. The initial effect component of this multiplier is simply 1.0. Suppose that in order to produce its product the establishment must purchase a number of goods and services from other firms in the region, which total $0.30 per dollar of output. Furthermore, suppose that the purchase of labor by the establishment represents an average expenditure of an additional $0.20 per dollar of output. The direct component of the multiplier is 0.50--the sum of the material and labor input coefficients.

The indirect effect component is simply the residual: 2.5 - 1.0 - .5, or 1.0 in this example. It represents all other rounds of expenditures in the region. For example, if the manufacturing establishment must purchase cardboard boxes (i.e., part of the direct effect), the manufacturers and distributors of these boxes must also purchase materials to produce the boxes. These additional expenditures are elements of the indirect effect.

The usual way to use the input-output model for regional impact analysis is to create an input-output model for the study region. This may be done on the basis of survey data; however, due to the cost and time involved in such surveys, secondary data sources are usually used. The RIMS procedure differs slightly from this usual approach. The direct effect component of the multiplier is estimated by scaling down the national I-O table to the regional level, using location quotients based on regional employment data. This step involves a methodology commonly used by researchers. However, the indirect effect estimation involves a somewhat different approach. Based on the finding that the indirect component can be estimated independently, the RIMS approach draws on additional information about the region to estimate the indirect effect that is not totally dependent on the estimates of the direct effect.

The principal advantage of the RIMS approach is this independent estimation of the indirect component. This means that the indirect component estimates do not depend completely on errors found in the estimate of the direct effect.

The current version of the BEA RIMS package, known as RIMS II, has abandoned this feature in favor of the more conventional estimation of the indirect component as part of the usual I-O approach (i.e., creating the Leontief inverse matrix.[41] Many researchers have pointed to the weakness of the direct effect estimates, and RIMS II allows these defects to carried over, in total, into their estimates of the indirect component. In contrast, RIMS introduces new information about the economy in estimating the indirect

[41]The RIMS II approach is described in J. Cartwright, R. Beemiller, and R. Gustely, RIMS II: Regional Input-Output Modeling System (Bureau of Economic Analysis, U.S. Department of Commerce, April 1981).

effect. The result is an estimate that is likely to be more consistent with the structure of the economy being modeled.

Direct Effect Estimation

The direct requirement coefficient matrix, or the A matrix, is a table of coefficients of the form

$$a_{ij} = \frac{X_{ij}}{X_j} \qquad \text{[Eq 17]}$$

where:

a_{ij} is the amount of commodity i used per unit of good j produced

X_{ij} is a sale from industry i to industry j

X_j is total sales for industry j.

Besides the usual I-O assumptions discussed earlier, the national matrix of technical coefficients is representative of the direct requirements for all industries, regardless of their location. In other words, it is assumed that the only difference between the national and regional A matrices stems from the fact that the region must import, primarily from other regions of the nation, the goods and services that are not produced in sufficient quantity to meet the technical requirement of local industries. In other words, it is assumed that the production function for the industry in the regions is identical to that for the national industry; the two columns of the A matrices for nation and region will differ only to the extent that the industry in the region will not be able to purchase all of its required inputs from sectors within the region. Thus, estimating the regional A matrix involves determining which of the technical requirements found in the national A matrix will be provided from within the region, and which will be imported.

The location quotient is a measure of the relative size of an industry in a region compared to that industry for the nation. Conceptually, the location quotient is given by

$$LQ_{ir} = \frac{X_{ir}/X_{.r}}{X_{i.}/X_{..}} \qquad \text{[Eq 18]}$$

where:

LQ_{ir} is the location quotient for industry i in region r

X_{ir} is total output for industry i in region r

. refers to a summation with respect to a subscript

(for example, $X_{.r}$ is total output for all industry in region r).

If the output of industry i in the region is $20 million, and the total regional output is $200 million, then the output of i represents 10 percent of the total regional output. At the same time, if in the nation as a whole, industry i output is 15 percent of total output, the location quotient will be .667. One could say that if regional demand for the output of industry i was related to the region's total output, the region is producing only two-thirds of the required output of i. Furthermore, if the technical requirement for the output of industry i (for example, industry j) is $0.06 per dollar of industry j output (taken from the national A matrix), it could be argued that the regional A matrix coefficient should be reduced to two-thirds of this amount, or to .04, to reflect the region's level.

On the other hand, had the location quotient been 1.2, it can be argued that production exceeds the regional requirements. In this case, the national technical coefficient would not be reduced, and the excess output of industry i would be exported to other regions of the nation.

This is essentially the approach that RIMS uses to regionalize the national A matrix. However, since there are no consistent and detailed data bases that include output as a measure, a proxy for output must be used. The most suitable proxy is employment. Under the assumption that output per worker in a given industry is the same in the region as in the nation, the regional location quotient is calculated as:

$$LQ_{ir} = \frac{E_{ir}/E_{.r}}{E_{i.}/E_{..}} \qquad \text{[Eq 19]}$$

where:

LQ_{ir} is the location quotient of industry i in region r

E_{ir} is total employment for industry i in region r

. refers to a summation with respect to a subscript.

The assumption of equal output per worker, which must use employment as a proxy for output, is merely an extension of the assumption that the technology of industry production in the region is the same as that of the nation. All that is added is the assumption that wage rates are the same.

The Bureau of the Census, County Business Patterns (CBP) employment file is the only suitable data source for regional employment.* However, this file has some deficiencies that must be overcome. First, coverage in certain industries is poor, notably in agriculture and railroad transportation. Thus, other sources must be used for these two industries. BEA data can be used for agriculture, and a combination of Population Census and Railroad Retirement Fund data can be used to provide an employment figure for railroads. Second,

*That is, the "published and unpublished" County Business Patterns data file from the U.S. Bureau of the Census.

Table 7

Characteristics of Sample I-O Models

Model and Year	Regional Definition	Number of Sectors	Household Row and Column Estimated	Sources*
Sullivan, PA - 1962	Sullivan County, PA	19	yes	1
Idaho - 1963	State of Idaho	16	no	2
Stockton, CA - 1962	Stockton Metropolitan Area	9	yes	3
Washington - 1963	State of Washington	27	no	4
Utah - 1963	State of Utah	39	yes	5
New Mexico - 1960	State of New Mexico	42	yes	6
Kansas - 1965	State of Kansas	69	yes	7
Clinton, PA - 1963	Clinton County, PA	38	yes	8
Bangor, ME - 1963	City of Bangor, ME	15	yes	9
Utah - 1947	State of Utah	26	yes	10
Itasca, MN - 1966	Itasca County, MN	28	yes	11
Nebraska - 1963	State of Nebraska	22	yes	12
Lansing, MI - 1958	Clinton, Easton, and Ingham Counties, MI	24	yes	13
St. Louis, MO - 1955	Madison and St. Clair Counties (IL): Franklin, Jefferson, St. Charles, St. Louis Counties, and St. Louis City (MO)	25	yes	14
Missouri - 1958	State of Missouri	34	yes	15
Oregon - 1963	State of Oregon	65	no	16
Arizona - 1958	State of Arizona	26	no	17
Sonoma County, CA - 1965	Sonoma County, CA	18	yes	18
United States - 1958	Continental United States	77	no	19

the CBP data represents just one pay period in March, and does not offer an average annual employment estimate. Many seasonal industries are operating at a relatively low level of output during March in some parts of the country. Therefore, it is necessary to find some more representative (though less detailed) source to be used in adjusting the CBP estimates. The BEA Regional Economic Information System (REIS) provides division-level employment for all counties in the United States. These division-level totals are used to adjust the CBP data.

Given the employment estimates, which are essentially done at the four-digit SIC level, the next step is to calculate the location quotients. Then the national A matrix can be regionalized. When summed, the columns of the A matrix representing the industries for which multipliers are to be calculated are the required direct component of the I-O multiplier.

The Indirect-Induced Effect Component

For I-O models, it has been found that the indirect component of the multiplier can be approximated adequately by a linear homogeneous function of the direct component. Moreover, in an I-O analysis framework, the induced component of the multiplier is simply an extension of the indirect component, introduced by adding a household row and column to the model. Conceptually, this addition augments the indirect interactions to account for changes in consumer income and expenditures. Thus, conceptually, the household sector does not differ from an ordinary industry in the model. For simplicity, reference to the indirect and induced components and to the indirect component will be interchangeable.

Verification of the Relationship. The hypothesis that the indirect component of the multiplier is well approximated by a linear homogeneous function of the direct component has been tested empirically. The regional input-output models listed in Table 7 constitute a wide range of situations for testing the hypothesis. Of the 19 models in the sample, 11 are for states or the nation. In terms of economic size, the sample I-O models include small areas, such as Sonoma County, California; a group of industrialized counties, such as St. Louis; and moderately industrialized states, such as Missouri. Also, considerable variety of industrial detail is offered. The national Kansas and Oregon models are composed of moderately disaggregated manufacturing sectors, while the other models (for instance, Sonoma and Nebraska) offer detail in the agriculture and food-processing sectors. In some examples, particularly the small-county models, the trade and service sectors are quite disaggregated. In other cases, the trade industries are represented by only one or two sectors.

Each of the 19 sample models was tested as an open model (i.e., with the household sector exogenous). Table 8 gives the results of regressing the indirect component on the direct component. For 13 of the sample I-O models, it was also possible to test the hypothesis on a closed model. The results of this regression analysis are reported in Table 9. Each industrial sector in each model was used as an observation. Each regression model was estimated both with and without a constant term. The case without a constant term is a direct test of the hypothesis that the indirect component of the multiplier is a linear homogeneous function of the direct component.

Table 8

Regression Results for Open I-O Models

MODEL	RESULTS WITH CONSTANT=0		CONSTANT TERM ESTIMATED		
	REGRESSION COEFFICIENT (T-RATIO)	R^2*	CONSTANT TERM (T-RATIO)	REGRESSION COEFFICIENT (T-RATIO)	R^2*
Sullivan	.171 (6.507)	.495	-.008 (.799)	.203 (4.230)	.513
Idaho	.300 (14.691)	.752	-.018 (1.277)	.360 (6.996)	.778
Stockton	.306 (31.558)	.981	-.015 (3.574)	.335 (32.576)	.993
Washington	.373 (19.974)	.860	-.031 (3.724)	.466 (15.907)	.910
Utah-1	.565 (30.711)	.876	-.061 (4.474)	.701 (20.572)	.917
New Mexico	.311 (13.266)	.627	-.017 (1.381)	.360 (8.507)	.635
Kansas	.556 (11.270)	.427	-.022 (.854)	.616 (7.156)	.433
Clinton	.229 (13.704)	.681	-.005 (.797)	.247 (8.871)	.677
Bangor	.137 (11.929)	.656	.005 (1.488)	.111 (5.418)	.686
Itasca	.256 (16.815)	.773	.007 (.859)	.240 (9.730)	.776
Nebraska	.324 (9.164)	.713	-.091 (3.396)	.734 (9.489)	.818
Lansing	.790 (14.152)	.455	.161 (5.199)	.841 (8.247)	.744
St. Louis	.340 (66.027)	.946	-.007 (1.789)	.368 (22.343)	.950
Utah-2	.508 (7.860)	.476	-.011 (.256)	.534 (4.384)	.453
Missouri	.454 (17.785)	.838	-.039 (3.139)	.542 (15.020)	.872
Oregon	.421 (48.192)	.873	-.022 (3.374)	.488 (22.860)	.891
Arizona	.485 (15.779)	.781	-.042 (2.049)	.561 (10.236)	.806
Sonoma	.629 (6.922)	.629	-.131 (3.509)	.925 (7.769)	.777
United States	1.081 (61.620)	.820	0.170 (4.990)	1.396 (21.440)	.860

Table 9

Regression Results for Closed I-O Models

Model	Results With Constant = 0		Constant Term Estimated		
	Regression Coefficient (T-Ratio)	R^2*	Constant Term (T-Ratio)	Regression Coefficient (T-Ratio)	R^2*
Sullivan	.608 (37.560)	.928	-.038 (1.820)	.677 (16.670)	.936
Utah - 1	2.309 (78.980)	.918	-.114 (6.370)	2.464 (21.130)	.920
New Mexico	1.670 (84.330)	.796	-.026 (0.250)	1.704	.792
Kansas	1.252 (52.950)	.823	-.077 (1.670)	1.322 (18.210)	.827
Clinton	1.066 (50.500)	.918	.010 (0.390)	1.048 (20.360)	.916
Bangor	1.395 (29.410)	.896	.035 (0.530)	1.334 (10.730)	.891
Itasca	1.100 (34.100)	.863	.024 (0.470)	1.065 (13.110)	.859
Nebraska	1.277 (30.960)	.846	-.153 (2.070)	1.528 (11.980)	.866
Lansing	4.008 (27.540)	.665	-.258 (0.510)	4.314 (6.950)	.654
St. Louis	1.623 (140.910)	.981	-.046 (1.710)	1.695 (38.980)	.983
Utah - 2	2.996 (62.770)	.851	-.395 (1.840)	3.475 (12.400)	.864
Missouri	2.620 (112.460)	.972	-.003 (0.050)	2.674 (34.050)	.971
Sonoma	1.040 (16.040)	.556	-.323 (1.890)	1.579 5.410)	.611

The results support the hypothesis. In most instances, the constant-term coefficients are not significantly different from zero; even when significant, the values are small and represent only a slight upward shift of the best fit line. Therefore, the constant term does not appreciably contribute to an explanation of the variance in the indirect component. At least 70 percent of the variance in the indirect components is explained by the direct component in 11 of the 19 open models without a constant term. Even more satisfactory results are obtained with closed models; for 11 of the 13 models, at least 80 percent of the variance in the indirect component is explained by the direct component without a constant term.

Theoretical Basis for the Relationship. One way to investigate the relationship between the direct and indirect components of the multiplier obtained from an I-O model is to consider the manner in which the (I-A) inverse is formed.[42] This is best done by viewing the (I-A) inverse as a power series of the A matrix, where

$$\lim_{n \to \infty} A^{o} + A^{1} + A^{2} + \ldots + A^{n-1} = (I-A)^{-1} \qquad \text{[Eq 20]}$$

where:

$\lim_{n \to \infty}$ is a mathematical notation meaning to evaluate the following function as the indicator (i.e., n) approaches infinity

A^{o} is the identity matrix

A^{1} is the matrix of technical coefficients

A^{n} is A raised to some power and n is the power

$(I-A)^{-1}$ is the Leontief inverse matrix.

Since the A^{o} term is the identity matrix, which represents the initial final demand change in the multiplier, and since A^{1} is the matrix of direct requirement coefficients, the column sums of which represent the direct-effect component of the multiplier, then the matrix of the indirect effect can be defined as

$$D = (I-A)^{-1} - (I+A) \qquad \text{[Eq 21]}$$

where:

D is the matrix of indirect-induced effect components of the Leontief inverse matrix

I is the identity matrix

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[42]This exposition demonstrates the basis of the relationship. For a proof, see F. Waugh, "Inversion of the Leontief Matrix by Power Series," Econometrica (April 1950), pp 142-154.

A is the matrix of direct requirements

$(I-A)^{-1}$ is the Leontief inverse matrix.

To investigate the form of the elements in this series, it will be useful to consider, as an example, the case of a 2 x 2 matrix, where

$$A^1 = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$$

and

$$A^2 = \begin{bmatrix} a_{11}a_{11} + a_{12}a_{21} & a_{11}a_{12} + a_{12}a_{22} \\ a_{21}a_{11} + a_{22}a_{21} & a_{21}a_{12} + a_{22}a_{22} \end{bmatrix}$$

The sum of the first column of A^2 (being one element in a sum that yields the indirect component of the multiplier for industry 1) is given by

$$a_{.1}^{(2)} = a_{11}(a_{11} + a_{21}) + a_{21}(a_{12} \cdot + a_{22}).$$

The quantity $a_{1}^{(2)}$ is the sum of the ith column, with the superscript denoting that the sum of products is associated with the A^2 matrix. This sum can be rewritten as:

$$a_{.1}^{(2)} = a_{11}\ (a.1) + a_{21}(a.2). \qquad \text{[Eq 22]}$$

Generally, a sum of products can be written as the sum of the values of one factor times the average value of the other factor, plus a covariance term. That is,

$$X_1Y_1 + Y_2Y_2 + \dots + X_nY_n = \sum_{i=1}^{n} X_i\overline{Y} + \sum_{i=1}^{n} (Y_i-\overline{Y} + \sum_{i=1}^{n} (X_i-\overline{X})(Y_i-\overline{Y}).$$

But since $\sum_{i=1}^{n}(Y_i-\overline{Y})$ *will always be zero*, this is more simply

$$\sum_{i=1}^{n} X_iY_i = \sum_{i=1}^{n} X_i\overline{Y} + \sum_{i=1}^{n} (X_i-\overline{X})(Y_i-\overline{Y}). \qquad \text{[Eq 23]}$$

Noting that the column sums of A^2 are sums of products of this form, Eq 23 can be expressed as follows:

$$ {}^{(2)}_{.1} = \left(\frac{a_{.1} + a_{.2}}{2}\right)(a_{.1}) + \sum_{i=1}^{n} \left(a_{i1} - \frac{a_{.1}}{2}\right)\left(a_{.i} - \frac{a_{.1} + a_{.2}}{2}\right). \quad \text{[Eq 24]} $$

The second term of Eq 24 is the covariance between elements of the first column of A and the column sums of A. If this covariance is zero because either the elements of the first column are the same or the elements of the column sums are equal, then the first column sum of A^2 is

$$ a^{(2)}_{.1} = \frac{(a_{.1} + a_{.2})}{2} (a_{.1}) = \alpha\, a_{.1} \quad \text{[Eq 25]} $$

In the same manner, the column sum of the second column of A^2 is

$$ a^{(2)}_{.2} = a_{12}(a_{11} + a_{21}) + a_{22}\,(a_{12} + a_{22}). $$

And, if a covariance term, similar to that of Eq 24 but referring to the second column, is equal to zero, this can be written as

$$ a^{(2)}_{.2} = \frac{(a_{.1} + a_{.2})}{2} (a_{.2}) = \alpha\, a_{.2}. \quad \text{[Eq 26]} $$

The α coefficients in Eq 24 and Eq 25 are identical, with both being the average of the column sums of A. This indicates that for the A^2 term of the power series (the first element used in determining the indirect effect matrix) the column sums are a linear function of the column sums of the A matrix--the matrix of the direct effects.

Similarly, for the A^3 term of the series,

$$ a^{(3)}_{.1} = a_{11}((a_{11}a_{11} + a_{12}a_{21}) + (a_{21}a_{11} + a_{22}a_{21})) + $$

$$ a_{21}\,((a_{11}a_{12} + a_{12}a_{22}) + (a_{21}a_{12} + a_{22}a_{22})), $$

which can be seen to be

$$ a^{(3)}_{.1} = a_{11}(\alpha^{(3)} a_{.1}) + a_{21}(\alpha^{(3)} a_{.2}). \quad \text{[Eq 27]} $$

Once again, if the covariance term similar to that of Eq 23 is zero, this can be written as

$$a_{.1}^{(3)} = a_{.1} \frac{\alpha a_{.1} + \alpha a_{.2}}{2} \alpha^2 a_{.1}. \qquad [\text{Eq } 28]$$

Summing the relation for the A^2 and A^3 terms of the series, with respect to the first column, yields

$$a_{.1}^{(2)} + a_{.1}^{(3)} = (\alpha + \alpha^{(2)} a_{.1}. \qquad [\text{Eq } 29]$$

Over the entire series then, the indirect effect associated with the first column is given by

$$d_{.1} = (\alpha^1 + \alpha^2 + \ldots + \alpha^{(n-1)} a_{.1} \qquad [\text{Eq } 30]$$

Similarly, for the second column, it is given by

$$d_{.2} = (\alpha^1 + a^2 + \ldots + \alpha^{(n-1)} a_{.2}. \qquad [\text{Eq } 31]$$

Predicting the Indirect-Induced Effect. The preceding *section showed* that the indirect component of the I-O multiplier can be adequately estimated as a linear function of the direct component of the multiplier for a given model. This section describes the methods used to predict, for a region without an input-output model, the probable level of the indirect component of the multiplier associated with a given direct component.

It was shown above that the coefficient relating the direct and indirect components will be related to the average of all direct-effect components. Associated with the first term of the power series is a scalar quantity that relates the sum of any column with the corresponding column sum of the A matrix. That is, α is simply the average sum of columns of the A matrix. The second term of the power series yields a scalar that relates the column sums of the A^3 matrix to the corresponding column sums of the A^2 matrix. Thus, what might be called an interdependency coefficient, α^*, is given by the sum of powers:

$$\alpha^* + \sum_{i=1}^{n-1} \alpha^i. \qquad [\text{Eq } 32]$$

where:

α^* is the interdependency coefficiency

α^i is the average technical coefficient for industry i.

However, the average of the direct requirement column sums is not known for a region without an I-O model. Therefore, it is necessary to find a suitable proxy or proxies for this variable. The average of the direct requirement coefficient column sums is a measure of the openness of the economy. An economy in which, on the average, only 20 percent of the value of inputs of each industry is contributed by other regional industries is much more open than one in which 80 percent of the value of inputs is associated with interindustry flows within the region. Thus, in the construction of this model, the relative size of an economy has been used as a principal explanatory variable.

Other factors may also be related to the degree of openness. For example, economies specializing in manufacturing may differ from those specializing in agriculture. Therefore, it is useful to consider the distribution of activity in the economy as a means of explaining the level of the indirect effect.

Using the sample of regional I-O models as a source of observations, regression analysis was used to predict the indirect component of the multiplier. A number of alternative approaches to the problem were investigated. Table 10 describes the specific variables that were included in alternative models as independent variables. About 500 observations on the dependent variable (the indirect effect) were assembled, each obtained by decomposing a multiplier from one of the 17 selected I-O models listed in Table 11. This sample differs from the one previously described in that the models here are generally consistent with one another in terms of the conventions and definitions on which they are based.

Table 12 summarizes the results obtained from the regression analysis with the dependent variable in log form. This permitted conformity with the least-squares linear-regression assumption that resulting residuals have a uniform variance throughout all ranges of the independent variable (the condition of homoscedasticity). This characteristic is needed to draw meaningful interpretations about measures of goodness of fit, such as the coefficient of multiple determination. Use of the dependent variable in a linear form produced a heteroscedastic pattern in the residuals, where their absolute magnitude was correlated with both the size and direct-effect variables.

Two equations were found to be superior to the others listed. In both cases, the same independent variables are included, although their coefficients differ. When predicting the indirect effect for open models (those with the household sector exogenous), the preferred form was found to be

$$\log M_{IO} = 0.14 - 0.54\, P_1 - 0.38\, P_2 + 0.0098 \log S_2 + 1.15 \log M_{DO} \quad \text{[Eq 33]}$$

where:

$\log M_{IO}$ is the natural logarithm of the indirect effect as determined by a sample of "open" input-output models

P_1 is the agriculture proportion of total nongovernment earnings

Table 10

Definition of Variables Used in Regression Analysis

Symbol	Description
C	Constant
P_1	Agriculture proportion of total nongovernment earnings
P_2	Manufacturing proportion of total nongovernment earnings
S_2	Size of economy relative to U.S. (regional nongovernment earnings divided by U.S. nongovernment earings)
I_8	Industry of multiplier = 1 if services; = 0 otherwise
I_7	Industry of multiplier = 1 if finance, insurance, and real estate; = 0 otherwise
I_6	Industry of multiplier = 1 if trade; = 0 otherwise
I_5	Industry of multiplier = 1 if transportation, communications and utilities; = 0 otherwise
I_4	Industry of multiplier = 1 if construction; = 0 otherwise
I_3	Industry of multiplier = 1 if mining; = 0 otherwise
I_2	Industry of multiplier = 1 if manufacturing; = 0 otherwise
I_1	Industry of multiplier = 1 if agriculture; = 0 otherwise
M_d	Direct component of multiplier
M_i	Indirect-induced component of multiplier
log S_2	Log of relative size of economy
log P_2	Log of manufacturing proportion
log P_1	Log of agriculture proportion
log $_d$	Log of direct-effect component

Table 11

Models Included in Sample

Sullivan County, Pennsylvania (1967)
Stockton, California (1964)
Utah-63 (1967)
New Mexico (1960)
Kansas (1969)
Clinton County, Pennsylvania (1966)
Bangor, Maine (1967)
Itasca County, Minnesota (1970)
Nebraska (1968)
St. Louis, Missouri (1959)
Utah-47 (1955)
Missouri (1958)
Sonoma County, California (1973)
Teton County, Wyoming (1967)
Upper Rio Grande, Texas (1973)
West Virginia (1070)
Charleston, South Carolina (1975)

Table 12

Regression Results

EQUATION NUMBER	R_2	COEFFICIENTS OF DEPENDENT VARIABLES (T-RATIOS)														
		C_1	P_1	P_2	S_2	I_8	I_7	I_6	I_5	I_4	I_3	I_2	I_1	H_d	LOG S_7	LOG H_d
A. OPEN MODELS																
1	.802	-95 (19.2)	-81 (4.6)	-.46 (.59)										2.18 (37.1)	.26 (22.6)	
2	.636	-1.94 (91.2)												2.62 (34.7)		
3	.681	-2.03 (93.1)			17.83 (9.8)									2.52 (35.3)		
4	.706	-1.81 (52.0)		-.74 (7.8)	19.40 (11.1)									2.40 (34.2)		
5	.707	-1.79 (43.7)	-.25 (1.2)	-.76 (7.9)	19.89 (11.1)									2.40 (34.2)		
6	.789	-1.18) (31.1)												2.25 (37.5)	.26 (22.3)	
7	.696		-2.6 (14.7)	-1.21 (14.1)										1.59 (25.6)	.43 (44.1)	
8	.804	-.32 (18.3)														1.35 (53.2)
9	.826	-.44 (18.9)			12.89 (9.6)											1.31 (53.5)
10	.874	.14 (4.3)	.54 (3.8)	-38 (6.1)											.0098 (18.2)	1.15 (50.4)
11	.784	-.61 (12.3)	-.14 (0.6)	-.58 (5.7)			-.01 (.3)	-.05 (1.1)	-.01 (0.2)	-.12 (2.0)	-.24 (4.0)	-.18 (4.9)	-.18 (3.6)			.85 (44.6)
B. CLOSED MODELS																
1	.608	-.80 (20.7)	.36 (2.7)	-.12 (2.1)			-.05 (1.3)	-.04 (1.5)	-.05 (1.7)	-.01 (0.4)	.05 (1.4)	-.09 (4.2)	-.01 (0.5)	1.04 (26.0)		
2	.561	-.74 (29.8)												.99 (25.4)		
3	.744	-.73 (42.2)			15.8 (18.9)									.96 (32.2)		
4	.789	-.73 (29.8)		-.24 (5.6)	16.3 (20.0)									.93 (30.6)		
5	.843	-.29 (13.5)												.91 (38.4)	.15 (29.9)	
6	.863	-.13 (4.8)	-.74 (8.7)	-.11 (3.2)										.89 (38.6)	.17 (32.1)	
7	.581	-.14 (11.1)														1.18 (26.4)
8	.766	-.04 (3.7)			15.6 (18.9)											1.13 (33.3)
9	.772	-.09 (6.9)		-.26 (6.2)	16.0 (20.2)											1.09 (32.0)
10	.843	51 (34.2)													.15 (29.0)	1.06 (38.5)
11	866	.63 (32.0)	-.79 (9.4)	-13 (4.1)											.17 (31.9)	1.03 (39.5)

P_2 is the manufacturing proportion of total nongovernment earnings

$\log S_2$ is the natural logarithm of the relative size of the local economy

$\log M_{DO}$ is the natural logarithm of the direct effect from an "open" input-output model.

According to Table 12, all of the parameter estimates of Eq 23 reject the null hypothesis that they are equal to zero with a 99 percent level of confidence. In addition, Eq 33 can explain 87.4 percent of the variability in the dependent variable. For "closed" input-output models (i.e., those with households augmented to the technical coefficients), the indirect-induced component is best predicted by the equation

$$\log M_{IC} = 0.65 - 0.79\, p_1 - 0.13\, p_2 + 0.17 \log S_2 + 1.03 \log M_{DC} \qquad \text{[Eq 34]}$$

where:

$\log M_{IC}$ is the natural logarithm of the indirect-induced component for "closed" input-output models

$\log M_{DC}$ is the natural logarithm of the direct effect from a "closed" input-output model.

Again, all of the estimated parameters for Eq 34 can reject the null hypothesis that they are equal to zero with a 99 percent level of confidence. Also, the equation can explain 86.8 percent of the variance in the dependent variables.

For either the open or closed model, with a given direct effect, the indirect component will:

1. Decrease as economic concentration in agriculture increases,

2. Decrease slightly as economic concentration in manufacturing increases

3. Increase as relative economic size increases.

These results are reasonable in that a larger and more diversified economy will be able to supply a larger share of the indirect requirements of a given activity.

Evaluating the Results. To validate the procedure, RIMS outputs were compared to those of 53 industrial sectors from six existing I-O models. The six models chosen for this test represent a wide variety of regions, both in terms of size and industrial specialization. The six models selected and the versions tested are: Kansas (open); St. Louis (closed); Sullivan County, PA (open); Washington (open); New Mexico (closed); and Nebraska (closed).

Sectors were randomly selected from each of these models in a structured scheme to provide for representation among the agricultural, manufacturing, mining and trade divisions. For each selected sector, the definition was

determined in terms of the national I-O sectoring plan. In most cases, aggregation was required to produce a multiplier for a specific industry corresponding to the regional model sector since the regional models were much more aggregated than the detailed national table. Weights derived from County Business Patterns data were used for this aggregation. Estimates of the direct effect component, the indirect effect component, and the multiplier for each sector are reported in Table 13, along with the survey results taken from the respective I-O models. Table 14 reports the means of subsamples of the RIMS and survey values, as well as the percent differences and the simple correlation coefficients. Several general features of these results are worth noting. The RIMS multiplier estimates are of the same order of magnitude as the survey values. Over the entire sample, the mean RIMS value is 2.021; the mean of the survey table multipliers is 2.0222. Generally, there is a downward bias in the estimates for closed models. Differences in agriculture and manufacturing sectors are small, and are somewhat larger for the trade sectors. In all cases, the correlation coefficients are reasonably high except for the estimates for open models.

The error found in the multiplier estimates is largely a function of errors in the direct-effect estimates. This is shown in the following regression relation:

$$E_m = -0.03 + 1.42\ E_d \qquad \text{[Eq 35]}$$

where:

E_m is the error between the survey-based multiplier and the RIMS estimate

E_d is the difference between the survey-based direct component and the RIMS estimate.

In this simple model, the variability of E can explain 85 percent of the variance in E_m.

These results underscore one advantage of the RIMS approach. No method has been found to produce I-O models from secondary data which will replicate the results obtained from building a model based on survey data. This has been demonstrated many times in the literature. Given how most surveys are done (i.e., relying on respondents to answer questions in such a way as to be consistent with the conventions of the input-output model--conventions that are not always consistent with ordinary business accounting), it could be argued that the survey results are not necessarily correct. However, this assertion would be hard to verify. Estimating a regional A matrix is a difficult task, whether by survey or from secondary sources. In the process, errors are certain to accrue.

The RIMS approach uses a fairly conventional method to estimate the direct requirement coefficient table. However, the estimation of the indirect component of the multiplier introduces new information about the economy which provides useful control totals. In other words, the errors introduced in the A matrix are not allowed to distort the indirect component to the extent that they would if the ordinary calculation of the Leontief inverse matrix were allowed to be the only source of this estimate. Experience with many regional

Table 13

Comparison of Survey and Estimated Multipliers and Components

MODEL	SECTOR	INDUSTRY	SURVEY DIRECT[1]	ESTIMATED DIRECT[2]	SURVEY INDIRECT[1]	ESTIMATED INDIRECT[3]	SURVEY MULTIPLIER[1]	ESTIMATED MULTIPLIER[4]
Kansas (open)	1-4	Ag.	.250	.479	.102	.179	1.352	1.658
	9-10	Ag.	.650	.718	.341	.282	1.991	2.000
	21-	Mfg.	.789	.848	.782	.339	1.571	2.187
	27	Mfg.	.082	.271	.027	.095	1.109	1.366
	44	Mfg.	.076	.366	.018	.133	1.094	1.499
	26	Mfg.	.109	.281	.052	.099	1.161	1.380
	29	Mfg.	.116	.625	.053	.242	1.169	1.867
	23	Mfg.	.543	.717	.226	.281	1.769	1.998
	15	Mining	.423	.264	.178	.092	1.601	1.356
	57-60	Trade	.274	.157	.108	.052	1.382	1.209
St. Louis (closed)	1	Mfg.	.327	.577	.597	.941	1.834	2.518
	6	Mfg.	.413	.716	.643	1.175	2.056	2.891
	9	Mfg.	.573	.606	.937	.989	2.510	2.595
	7	Mfg.	.213	.397	.316	.640	1.529	2.037
	10	Mfg.	.479	.658	.773	1.077	2.252	2.735
	13	Mfg.	.850	.733	1.028	1.203	2.678	2.936
	20,26	Trade	.774	.716	1.256	1.175	3.030	2.891
Sullivan (open)	1	Ag.	.179	.072	.014	.006	1.193	1.078
	2	Mfg.	.361	.128	.069	.011	1.430	1.139
	3	Mfg.	.102	.146	.006	.013	1.108	1.159
	4	Mfg.	.103	.356	.009	.035	1.112	1.391
	5	Mining	.171	.188	.007	.017	1.178	1.205
	10-13							
	18	Trade	.085	.051	.006	.004	1.091	1.055
Washington (open)	1	Ag.	.183	.459	.047	.194	1.230	1.653
	2	Ag.	.326	.661	.150	.292	1.476	1.953
	10	Mfg.	.368	.544	.179	.235	1.547	1.779
	9	Mfg.	.499	.404	.195	.168	1.694	1.572
	13	Mfg.	.104	.370	.022	.153	1.126	1.523
	7	Mfg.	.099	.509	.019	.218	1.118	1.727
	6	Mfg.	.405	.448	.148	.189	1.553	1.637
	20	Mfg.	.105	.297	.026	.120	1.131	1.417
	4	Mining	.643	.227	.327	.089	1.970	1.316
	25	Trade	.174	.174	.043	.066	1.217	1.240
New Mexico (closed)	5	Ag.	.893	.846	1.416	1.208	3.309	3.054
	2	Ag.	.913	.713	1.818	1.013	3.731	2.726
	20	Mfg.	.856	.701	1.478	.995	3.334	2.696
	16	Mfg.	.640	.388	1.118	.541	2.758	1.929
	17	Mfg.	.710	.539	1.119	.759	2.829	2.298
	18	Mfg.	.669	.532	1.070	.749	2.739	2.281
	15	Mfg.	.708	.508	1.357	.714	3.065	2.222
	19	Mfg.	.354	.445	1.414	.623	3.268	2.068
	9	Mining	.688	.434	1.104	.607	2.792	2.041
	31-34	Trade	.814	.689	1.320	.977	3.134	2.666
Nebraska (closed)	2	Ag.	.541	.566	.653	.713	2.194	2.279
	1	Ag.	.740	.862	1.018	1.099	1.758	2.962
	6	Mfg.	.859	.885	1.422	1.130	2.281	3.015
	8	Mfg.	.392	.627	.492	.793	1.384	2.420
	7	Mfg.	.757	.804	.869	1.024	2.626	2.828
	5	Mfg.	.810	.923	1.358	1.180	3.168	3.103
	10	Mfg.	.503	.499	.605	.626	2.108	2.125
	13	Mfg.	.280	.402	.320	.501	1.600	1.903
	4	Mining	.404	.457	.444	.572	1.348	2.029
	15	Trade	.691	.659	.786	.834	2.477	2.493

[1] *Components and multipliers from specified regional models.*

[2] Estimated direct based on regionalized national direct.

[3] Estimated indirect (equal to indirect plus induced for closed models) based on relationship with estimated direct.

[4] Estimated multiplier equal to one plus estimated direct plus estimated indirect.

Table 14

Summary Comparison of Results

MEASURE	ALL OBSERVATIONS	OPEN MODELS	CLOSED MODELS	TRADE SECTORS	AGRICULTURE SECTORS	MANUFACTURING SECTORS
MEAN OF SURVEY VALUES	2.022	1.399	2.622	2.055	2.137	2.006
MEAN OF RIMS VALUE	2.021	1.514	2.509	1.926	2.151	2.068
PERCENT DIFFERENCE OF MEANS	0.1%	8.0%	4.3%	6.3%	0.7%	3.1%
CORRELATION BETWEEN SURVEY AND RIMS VALUES	.82	.71	.84	.98	.88	.79

studies shows that the resulting multipliers tend to be lower. Given that most secondary data methods tend to produce multipliers that are larger than survey-based tables, this advantage of the RIMS approach would seem to be significant.

Multiplier Disaggregation

The RIMS procedure outlined above provides a means for estimating a regional industry-specific multiplier. RIMS also provides a means for disaggregating the total effects (measured in terms of output, earnings, and employment) into the industrial composition of that change.

The approach used creates the entire regional direct requirement coefficient table--the A matrix for the region, in which the selected industries (those for which multiplier calculations are desired), are represented as individual rows and columns. With this full A matrix, it is then possible to calculate the Leontief inverse matrix. The columns of the Leontief inverse matrix representing the selected industries are an approximation of the total multiplier's distribution.

The RIMS-estimated indirect component of the multiplier is then distributed across industries in the same pattern found in the selected industry column. The multiplier column is therefore the sum of the direct column, with 1.0 added to the diagonal element, and of the indirect column.

RIMS Database

National Input-Output Table

The most important element of the RIMS database is the modified version of the Bureau of Economic Analysis (BEA) national input-output table. This table, estimated for 1972, contains 496 sectors in its original form. Two types of modifications were made to this table to make it suitable for the RIMS applications. First, several sectors were either aggregated or deleted; second, the table was converted from one which is defined in terms of comodities to one defined in terms of industries. The first modification is necessary to reflect the fact that certain national I-O table industries do not have a readily available regional data source. The second is necessary because regional data used for scaling down the national table to the region is available only on an industry basis.

Aggregations and Deletions. One sector--the BEA I-O industry 710100 - Owner Occupied Housing--was deleted from the national table. This sector, which is necessary in the national table for consistency with the U.S. National Income Accounts, is not useful in regional impact analysis. The national column is somewhat artificial, with a large portion of the transactions being imputed. Thus, no actual money transactions are associated with many of these elements. As such, the sector is useful in regional impact analysis, but there is no way to characterize regional differences in its value for use in a regional table.

The detailed agriculture sectors of the 496-sector national table have also been aggregated to one sector for RIMS. This was necessary because no suitable database is available at the county level which lends itself to the interactive use anticipated for the package. The Census of Agriculture data does not always match the sector definitions in the national table; also, use of the detailed agriculture sectors in analysis almost always requires some investigation, drawing on a number of sources and evaluating them in light of the characteristics of the impact study at hand. Therefore, the detailed sectors have been aggregated into one agriculture sector for which county-level data exists for regionalization of the national table.

Converting Commodities to Industries. The processing sectors of the 1972 detailed (496-sector) BEA national input-output model are defined in terms of commodities. That is, the definitions of the rows of the table are in terms of commodities produced rather than the industries which produce them. The columns of the table, which relate to consumers of these commodities, are defined in terms of industries.

A firm is assigned to an industry on the basis of its primary product (i.e., commodity which represents the predominant output). However, at the same time, a given firm or industry may produce other commodities which are secondary products to that particular industry, but primary to another industry. For example, in the 85-order national I-O table, sector 27 is the commodity labeled "Chemicals and Selected Chemical Products." As a column, this sector is defined as the Chemical and Selected Chemical Products industry. This industry itself produces about 86 percent of the commodity which is its primary product. However, other industries also produce this commodity, and

for them, it is a secondary product. About 2 percent is produced by the Plastics and Synthetic material industry, another 6 percent by the Petroleum Refining industry, and so on. In the 85-sector table, about 30 industries produce some of this commodity category, although in most cases, the percentage of the total is quite small; more than half of the industries produce less than 0.1 percent of the total.

In contrast to the commodity definitions in the national I-O table, the information relating to the availability of inputs in a region is collected and reported by industry. This regional information is the basis for making adjustments to the rows of the national table down to the region. Thus, converting the national I-O table from a commodity-by-industry table to an industry-by-industry basis is essential to applying this table to regional impact analysis in RIMS.

The table is converted by multiplying the commodity-by-industry table (called the use table) by a table which shows the distribution of industry production of a given commodity (called the make table). Both of these tables are available at the 496-sector level of detail.

For example, suppose the use table shows that industry j requires $10 of commodity m. Furthermore, the make table reveals that 10 percent of commodity m is produced by industry r, 20 percent by industry s, and 70 percent by industry t. Converting this element of the use table to an industry-by-industry basis involves distributing the $10 by the proportions found in the make table: $1 from industry r, $2 from industry s, and $7 from industry t. Repetition of this redistribution for every element in the table produces the national table in the correct form for RIMS. Dividing each element of the resulting transactions table by the gross output of the industry represented by that column produces the national matrix of direct requirement coefficients, or the A matrix. It is this national matrix, with the deletions and aggregations described above, that is the I-O table of the RIMS database.

Personal Consumption Expenditures (PCE)

RIMS is based on an input-output model that is closed with respect to households. (That is, households are considered to be an endogenous industry of the model.) This is done by including in the model a row and column to represent local households: their provision of labor to other industries in the region (the row), and their purchases of consumption goods and services from local industry (the PCE column). The estimates in the row are not region-specific; their source was discussed on p 76. This section concerns the source of the state PCE columns and their use in RIMS.

The original source of the state PCE estimates by industry is an unpublished BEA study which created such estimates for the 1967 input-output model input to the BEA version of RIMS. These estimates were based on an uncompleted effort to create regional accounts at the state level, similar to those produced at the national level by BEA. The basis of the state consumption patterns was a set of consumption-by-commodity estimates, based on the Bureau of Labor Statistics Consumer Expenditure Survey. These commodity expenditures were updated to 1967 and converted to an industry basis using the national input-output model bridge table between commodities and industries. Certain conventions of the input-output table were also applied to the data, such as

the representation of the sales of the trade industries as being the marketing margin of that distribution activity.

Updating these 1967 estimates to 1972 involved two steps. First, the ratio of 1972 to 1967 national PCE was applied to the 1967 values to reflect aggregations done to make the column conform to the 1972 sectoring plan. Where disaggregation was required, the distribution of the 1972 national PCE was applied to the 1967 state coefficient to produce the required detail for 1972.

The state PCE estimates represent the oldest data in the database in the sense that their basis is a somewhat outdated consumer expenditure survey. Furthermore, even with updating to 1972 (data which is now 12 years old), a number of changes in the economy, particularly those relating to energy prices and the pattern of energy consumption, are not included. The early revision of this data file would be the most important improvement that could be made in the package. A crude, though essentially credible, update could be done by using the updated BEA 85-sector table. Such a table now exists for 1974, and begins to account for the energy price changes that began in the previous years.

While the 85-sector table is certainly less detailed than the I-O table in the RIMS database, a number of the energy-related sectors are the same in both tables. For example, the same level of aggregation exists in each table for Crude Petroleum and Natural Gas, Coal Mining, and Auto Repair and Service. Furthermore, the 85-sector industry called Petroleum Refining and Related Industries is predominantly the detailed sector called Petroleum Refining. Unfortunately, the 85-sector table includes only one aggregated Utility sector. Yet, even with this aggregation, there would be some benefit to using this data for 1974 to update the state PCE file.

Earnings and Employment Coefficients

RIMS produces impacts in terms of both earnings and employment, by industry. Both of these results are transformations of the output change--the fundamental result of input-output impact analysis. To provide these earnings and employment effects, which in most cases are much more meaningful to the analyst than the output changes, coefficients are required for each detailed I-O industry. The RIMS database contains such coefficients for each of the 421 detailed sectors. These coefficients are appended to the I-O table to facilitate processing.

Both sets of coefficients are based on national data taken from several sources. The earnings coefficients, defined as the ratio of earnings paid to households by an industry-to-industry gross output, plays a dual role. It is first used as the household row coefficient for the closed regional I-O model, and secondly for converting output changes, by industry, to changes in earnings by the households of the region.

The earnings coefficients are based on both the 1972 and 1967 BEA national I-O tables. First, employee compensation for the detailed 1967 table

was adjusted to earnings, using BEA data. Dividing these earnings by industry gross output for each detailed industry gave a 1967 earnings coefficient vector.

Next, employee compensation proportions of gross output in the 85-sector 1972 table were used to adjust the 1967 vector. After converting the 1972 employee compensation to earnings, the 496-sector gross outputs were used to create a weighted 85-sector coefficient vector based on the 1967 coefficients. Differences between this 1967-based vector and the actual values were used to adjust the underlying detailed 1967 vector.

An updating of these earnings coefficients would be advisable when the components of value added become available for the detailed 1972 national table.

The employment coefficients are simply the ratio of employment to gross output for each detailed industry. The Bureau of the Census County Business Patterns employment file was used to obtain them. In the current RIMS data base, these estimates are based on 1972 data.

The employment coefficients are the only elements of the RIMS database that are sensitive to the year of the dollars of final demand that are used in the impact analysis run. This follows from the fact that the ratio is not dimensionless, as is the case with the I-O coefficients themselves (including the earnings coefficients). Currently, the employment coefficients represent workers per dollar of gross output, with gross output measured in 1976 dollars. Thus, since the employment coefficients refer to 1976 dollars, so must the final demand change that is entered, if the result is to reflect the correct level of employment change.

To make these coefficients more consistent with the user-friendly interactive process environment, two changes are recommended. First, the employment coefficients themselves should be adjusted to 1981-82 dollars. Second, RIMS should allow the user to specify the date of the dollars, with current dollars being a default. With a specification of other than current dollars by the user, the program could draw on a small database to convert the employment coefficients to the correct data.

4 DEFENSE LOGISTICS AGENCY EMPLOYMENT IMPACT SYSTEM

Introduction

The Defense Logistics Agency (DLA) Employment Impact System is a computer-aided, industry-specific regional employment impact system. It was developed by CERL to help DLA report the regional employment impacts of their contracting activity to Congress. The DLA Employment Impact System not only provides a likely range of the workers to be hired or laid off by the contractor because of a contract award, but it also estimates the total employment impact on the local economy resulting from DLA contracting activity. With only four pieces of information (i.e., the regional definition, the product code of the commodity being produced, the dollar value of the contract bid, and the contractor's estimate of his labor requirement), the employment impact from a contract award can be evaluated.

As a result of the economic downturn following the Korean War, President Truman directed that some government procurements be set aside for award in labor surplus areas (LSAs) to relieve their economic distress. Subsequently, the Maybank Amendment was issued, which exempted DOD from this requirement. Thus, until 1981, each annual DOD Appropriations Act has specifically prohibited DOD from setting aside or paying price differentials to relieve local economic dislocations.

However, through recent efforts of a coalition of Northeast and Midwest Congressmen, DOD has been directed to test a modification to the Maybank restriction. Specifically, the 1981 DOD Annual Appropriations Act (Public Law 96-527) requires that DLA test a program of awarding certain contracts to firms that agree to perform the contracts in LSAs. The purpose of the test (popularly referred to as the DLA Maybank Test) was to increase the award of DLA contracts in LSAs even if it required paying a price differential of up to 5 percent over a lower, non-LSA bidder. The test also required DLA to measure the effects of these awards as they impact on employment in both the gaining LSA and the losing non-LSA and to report the results to the Appropriations and Armed Services Committees of the House and Senate. This test has been continued with each annual DOD Appropriations Act since 1981.

The following text explains the methodology of the DLA Employment Impact System. This includes (1) the procedures used to determine the range of the number of workers to be hired or laid off because of a contract award (called the Employer's Representation Check), and (2) the method used to estimate the total employment impact in the economies of the regions affected by DLA contracting activities (called the Employment Impact Estimate).

The Employer's Representation Check

Since one of the major purposes of the DLA Maybank Test is to measure the impact that contract awards made under the test have on employment levels, it is important to establish the number of employees required to perform a given contract. Thus, DLA requires that all bidders submitting solicitations complete an "employer's representation." The employer's representation attests to the bidder's intention regarding (1) the number of employees likely to be

laid off if the bidder does not receive the contract award, and (2) the number of new workers that will be hired if the bidder is awarded the contract.

Not long after the test began, some highly suspect employer's representations were received that clearly indicated that contractors did not understand this requirement. Experience to date has shown that this method of determining the contractor's labor requirement has several problems. The major ones are:

1. There is a tendency for bidders to exaggerate the employer's representation, possibly in the mistaken belief that it is a factor for the contract award. For example, it is not uncommon to have a bidder state that 50 new workers will be added if a contract for $20,000 is awarded; obviously, this appears out of proportion.

2. There have been problems with contractors counting parttime workers as fulltime employees.

3. Contractors are sometimes unable to accurately estimate the level of employment on an annual basis, especially for contracts with short performance periods.

4. There are difficulties in determining the employment impact in the manufacturer's labor market area.

There are at least two ways of verifying employer's representation estimates. One is to compare it with an employment estimate computed by dividing the dollar value of the contract bid by the contractor's average annual wage bill. The average wage bill should not only include the annual wages and salaries of employees, but also their fringe benefits and employer's contributions to employee-related government programs. Presumably, the average annual wage bill should also be computed for workers employed in firms that are both classified in the same industrial category and located in the same geographic area as the bidder. An employment estimate computed in this way represents the maximum number of employees, on the average, that could possibly be hired or laid off due to a sale equal to the value of the contract bid.

Although this method is simple and provides a gross "ball park" estimate of the largest employer's representation to be expected of a specific dollar value for a contract bid, it does suffer from at least two deficiencies. First, data are generally not available to compute fringe benefits and employer's contributions to employee-related government programs for industrial categories to a regional level such as a county. Second, one could make them up by some "rule of thumb" (such as 30 percent of wages and salaries). Either way, one would be required to ignore them or to generate questionable estimates. Consequently, in practice, this method is likely to derive either greatly exaggerated or highly questionable employment estimates for comparison to the estimates supplied by contract bidders.

Second, the DLA Employment Impact System uses a simple but accurate method to verify employer's representation estimates submitted with contract solicitations. If the contract is awarded, a bid represents a sale to the bidder, and he/she is expected to deliver a product or service for the agreed price (i.e., the contract value). With the revenue from the contract award,

the bidder is presumed to cover all his costs, including payments to labor, rents, taxes, purchase of materials and supplies, etc., and a profit as well. As a result, a natural way of verifying employer's representation estimates is to compare the dollar value of sales to the number of workers employed ratio with the ratio of the dollar value of the contract bid to the employer's representation estimate. Thus, this figure is the ratio of the dollar value of the contract bid to its employer's representation estimate compared with the minimum and maximum dollar value-of-shipments (i.e., sales) per worker ratios observed for the bidder's industrial classification and geographic location.

This method relies heavily on the assumption that firms tend to have relatively constant relationships between the dollar value of their sales and the number of workers employed at all levels of production. In other words, as a firm expands and contracts its production levels, it also expands and contracts the number of workers it employs roughly in proportion to the change in production. The sales of a firm and its production level are considered synonymous.

Even though firms are assumed to have constant salesp-per-worker rations, one cannot conclude that the relationship between the dollar value of sales and the number of firms is constant for all firms classified within an industrial category. Hence, the DLA Employment Impact System uses a range of sales-per-worker ratios to evaluate the reliability of an employer's representation estimate. In fact, variation for firms within industrial categories should be expected for no other reason than that all industrial categories, no matter how finely they are classified by product line, have some degree of heterogeneity. But even if one were able to define industrial categories with perfectly homogeneous product lines, variation in the sales-per-worker ratios should still be expected because technological differences are known to exist by firm and across different areas of the United States. These differences result from factors such as age of the machinery used in the factories, differences in transportation costs, differing qualities of the local labor force, local access to cheap labor or raw materials, local concentrations of other firms that provide needed materials and supplies, and "agglomeration economies" that result in cost advantages.*

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*Agglomeration economies is a term used in regional and urban economic analysis that refers to comparative cost advantages that derive from firms located in concentrations of firms in the same industry or in large urban-industrial complexes. Agglomeration may be classified into four general categories: transfer economies, internal economies of scale to the firm, external economies of scale to the firm that are internal to the industry, and external economies of scale to an industry. Generally, the comparative cost advantages derive from two sources. First, a firm locating among other firms engaged in the same activity may be able to reduce the cost of training workers if the area has a labor pool with unique skills or has special educational facilities. Also, heavy concentrations of firms of one industry in an area often attract ancillary activities that provide a cheap source of materials and services useful to the area's main productive activity. Second, there are benefits that arise due to firms locating in large urban-industrial complexes. Frequently called "infrastructure," these benefits arise from the access to highways, railroad lines, airport terminals, utilities, commercial and financial institutions, research and educational institutions, and other services that would not normally be found in less well-developed, smaller places. Good discussions of agglomeration economies can be found in Hoover (1948), Isard (1956), Nourse (1968), and Smith (1981).

The extent and magnitude of the industrial and spatial variation in sales-per-worker ratios are given in Table 15 (1977 Value-of-Shipments per Worker Statistics by SIC). "Value-by-shipments" is a term meaning the dollar value of sales for manufacturing establishments* and SIC stands for Standard Industrial Classification.** Table 15 presents a variety of sales per worker statistics for manufacturing firms that were compiled from the 1977 Census of Manufacturers[43] (the most current available). The data included the value-of-shipments (in thousands of 1977 dollars) and employment*** by manufacturing industry (at the two-digit SIC level) taken from firms in 277 Standard Metropolitan Statistical Areas (SMSAs). An SMSA is an urban area defined by the U.S. Office of Management and Budget for collecting and analyzing many types of demographic, economic, and social information. The column entitled "freq" includes the number of firms in the sample of SMSAs for each industrial category. The columns entitled "mean," "min," "max," and "range" provide the average, smallest, largest, and range of observed value-of-shipments-per-worker ratios for the firms of each SIC category (all in thousands of 1977 dollars). The figures show that not only do value-of-shipments ratios vary by industrial category, but they also indicate a large degree of variation both within industrial classification and across regions of the country.

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*Value-of-shipments covers the received or receivable net selling values, f.o.b. plant (exclusive of freight and taxes), of all products shipped, both primary and secondary; it includes all miscellaneous receipts, such as receipts for contract work pe formed for others, installation and repair, sales of scrap, and sale of products bought and resold without further processing. Included are all items made by or for the establishments from materials owned by it, whether sold, transferred to other plants of the same company, or shipped on consignment. The net selling value of products made in one plant on a contract basis from materials owned by another was reported by the plant providing the materials. In the case of multiunit companies, the manufacturer was asked to report the value of products transferred to other establishments of the same company at full economic or commercial value (i.e., including not only the direct costs of production but also a reasonable proportion of "all other costs," including company overhead and profit).

**The Standard Industrial Classification (SIC) defines industries by types of activity in accordance with the composition and structure of the economy and covers the entire field of economic activities. It is revised periodically to reflect the changing industrial composition of the economy. The present revision, for the year 1972, is the fist major one since 1957. See <u>1972 Standard Industrial Classification Manual</u> (Office of Management and Budget).

***Employment includes all full-time and part-time employees on the payrolls of operating manufacturing establishments during any part of the pay period ending nearest the 12th of the months specified on the report form. Included are all persons on paid sick leave, paid holidays, and paid vacations during these pay periods. Officers of corporations are included as employees; proprietors and partners of unincorporated firms are excluded. The "all employees" number is the average number of production workers plus the number of other employees in mid-March. The number of production workers is the average for the mid-month payroll periods of March, May, August, and November.

[43] <u>1977 Census of Manufacturers: Geographic Area Series</u> (Bureau of Census, U.S. Department of Commerce).

Table 15

1977 Value-of-Shipments per Worker Statistics by SIC

SIC	freq	mean	min	max	range
		-------------	$1,000	-------------	
20-39 Total Mfg	268877	67.8	33.1	502.4	469.3
20 Food & Kindred Prod	13686	124.6	42.4	337.1	294.7
22 Textile Mill Prod	1528	43.6	22.8	78.7	56.0
23 Apparel	3849	32.9	8.3	74.6	66.4
24 Lumber & Wood Prod	3465	62.7	26.3	103.0	76.7
25 Furniture & Fixtures	2434	40.3	22.8	70.3	47.6
26 Paper & Allied Prod	3699	72.5	34.0	169.5	135.5
27 Printing & Publishing	23667	48.4	21.5	71.1	49.6
28 Chemicals	8571	126.9	54.0	345.8	291.8
29 Petroleum Refining	731	491.6	100.2	1762.0	1661.8
30 Rubber & Plastic Prod	4953	52.2	19.3	124.2	104.8
31 Leather Goods	447	34.8	19.0	61.0	42.0
32 Stone, Clay & Glass Prod	7937	61.1	26.0	147.3	121.4
33 Primary Metal Prod	4653	83.9	28.7	196.0	167.3
34 Fabricated Metal Prod	20528	57.4	28.0	138.8	110.8
35 Nonelectric Machinery	27531	57.0	23.7	142.0	118.4
36 Electric Machinery	9445	49.3	26.0	76.6	50.6
37 Transportation Equip	4665	86.0	28.4	211.8	183.3
38 Instruments	3245	46.3	19.0	102.7	83.7
39 Misc Mfg	3910	43.1	23.9	71.7	47.8

Source: 1977 Census of Manufacturers (data from 277 SMSA's)

The DLA Employment Impact System exploits the industrial and spatial variation of the value-of-shipments ratios by compiling sales-per-worker ratios that are unique both to the industry in which the contracted product is made and to the geographic area in which the commodity's producer is located. Furthermore, the DLA Employment Impact System uses an approach to compute both the minimum and maximum sales-per-worker ratios likely to be found for producers of similar goods within the same geographic area. This is done by assuming a constant relative distribution of sales-per-worker ratios by size of firm for the same industrial category as the contracted product at the national level.

The procedures used by the DLA Employment Impact System to compute the minimum and maximum sales-per-worker ratios are presented in Table 16 (Value-of-Shipments per Worker Calculations for Non-Textile Bags (SIC 2643 Mode in Los Angeles-Long Beach SMSA). The statistics shown in Table 16 are classified according to firm size, as measured by the annual average number of workers employed by firms producing non-textile bags (SIC 2643). At the U.S. level, Table 16 provides the number of workers, the dollar value-of-shipments, and the value-of-shipments-per-worker ratios by firm size and in total for non-textile bag producers. The column entitled "value-of-shipments-per-worker relative to U.S. total" is the distribution of value-of-shipments-per-worker ratios by size of firm relative to the sales-per-worker ratio for all firms producing non-textile bags within the United States. The distribution of sales-per-worker ratios by firm size for firms producing non-textile bags in the Los Angeles-Long Beach SMSA is estimated by applying the distribution of sales-per-worker ratios relative to the United States total to the value-of-shipments-per-worker ratio for all firms producing non-textile bags in the Los Angeles-Long Beach SMSA. An implicit assumption is that the relative distribution of sales-per-worker ratios for an industry by firm size is the same for a region as it is at the national level. After these computations are complete, the DLA Employment Impact System then chooses the minimum and maximum estimated sales-per-worker ratios as the range of sales-per-worker ratios to verify the employer's representation estimate. For the example of non-textile bag producers in the Los Angeles-Long Beach SMSA, $64,200 is the minimum sales-per-worker ratio and $77,000 is the largest value-of-shipments-per-worker ratio. Note that $68,000 is the expected or average sales-per-worker ratio for all firms producing non-textile bags in the Los Angeles-Long Beach SMSA.

To actually carry out an employer's representation verification check, the DLA Employment Impact System deflates the current-dollar value of the contract bid to reflect the price level of 1977 using an appropriate product-price deflator.[44] This procedure results in a constant-dollar contract bid in terms of 1977 dollars. Next, a maximum range of estimated employment values is computed by dividing the constant-dollar contract bid by the maximum and minimum sales-per-worker ratios. Finally, the employer's representation estimate is compared with the range of estimated employment values. If the employer's representation estimate falls within the range, then it is presumed to be reasonable. On the other hand, if the employer's representation

[44] Input-Output Time Series: Output, Prices, and Employment (Bureau of Labor Statistics, U.S. Department of Labor, 1981).

Table 16

Value-of-Shipments per Worker Calculations for Non-Textile Bags (SIC 2643)
Made in Los Angeles-Long Beach SMSA

Firm size by number of workers	U.S. Level: Number of workers (1,000)	U.S. Level: Value-of-Shipments ($million)	Value-of-Shipments per Worker: U.S. Level ($1,000)	Value-of-Shipments per Worker: Relative to U.S. total	Value-of-Shipments per Worker: LA-LB SMSA ($1,000)
all firms	48.7	3,482.3	71.5		68.0
1-4	.2	13.5	67.5	.94406	64.2
5-9	.4	31.3	78.3	1.09510	74.5
10-19	1.1	89.1	81.0	1.13287	77.0
20-49	3.8	278.4	73.3	1.02517	69.7
50-99	6.4	465.2	72.7	1.01678	69.1
100-249	15.7	1,068.4	68.1	.95245	64.8
250-499	12.8	974.4	76.1	1.06434	72.4
500-999	8.3	562.1	67.7	.94685	64.4

Source: 1977 U.S. Census of Manufacturers (1977 dollars)

estimate falls outside the estimate range, then the employer's representation estimate may be invalid or, at least, questionable.

Employment Impact Estimation

The DLA Employment Impact System carries out a regional employment impact analysis using a region/industry-specific employment multiplier. These multipliers consider both the unique nature of the geographic area and its industrial structure where the product is made, as well as the technical process used to manufacture the commodity. Like the economic base multiplier, a region/industry-specific multiplier estimates the secondary employment effects (both indirect and induced) that are caused by an initial change. However, unlike the economic base multiplier, a region/industry-specific multiplier is unique to the industrial sector that is initially affected by an autonomous change.

The region/industry-specific employment multiplier is computed using two complementary methodologies. First, a region/industry-specific output multiplier is computed using the procedures described in Chapter 3.[45] Second, the region/industry-specific output multiplier is converted into a region/industry-specific employment multiplier using a simple procedure[46] in which such a multiplier for an industry (industry j, for example) is

$$\Psi_{ej} = 1.0 + \frac{\bar{e}}{e_j} (\Psi_{qj} - 1.0) \qquad \text{[Eq 36]}$$

where:

Ψ_{ej} = is the region-specific employment multiplier for industry j

$\bar{e}$ = is the average ratio of employment to output for all industries in the region

e_j = is the ratio of employment to output for industry j

Ψ_{qj} = is the region-specific output multiplier for industry j (computed by the RIMS methodology).

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[45] Also see R. L. Drake, "Relationship Between Direct and Indirect Components of Input-Output Multiplier" (a paper delivered at the 1974 meeting of the Western Regional Science Association); and R. L. Drake, "A Short-Cut to Estimates of Regional Input-Output Multipliers: Methodology and Evaluation," International Regional Science Review (Fall 1976), pp 1-17.

[46] See R. L. Burford and J. L. Katz, "On the Estimation of Value Added, Income, and Employment Multipliers Without a Full Input-Output Matrix" (a paper presented at the 1978 meetings of the Southern Economic Association).

5 SUMMARY

This effort documents the methodologies behind the development of three types of regional economic modeling tools to be included as part of EIFS: the Bureau of Reclamation Economic Analysis Model (BREAM), the Regional Industrial Multiplier System (RIMS), and the DLA Employment Impact System. These enhancements will increase the overall utility of EIFS to a wide variety of ETIS users involved in economic and social impact assessment. These improved capabilities will make technological advances in the field of regional economic impact analysis available to the ETIS user community as an integrated system. The prospective users should analyze these proposed techniques and approaches, evaluate their utility, and provide comments for improving their integration into EIFS.

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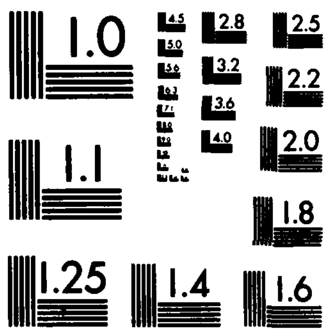

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